State of California
Natural Resources Agency
DEPARTMENT OF WATER RESOURCES
Division of Integrated Regional Water Management

Site Characterization and Groundwater Monitoring Data Analysis Summary Prospect Island Tidal Habitat Restoration Project Solano County, California

North Central Region Office

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Memorandum Report
January 2014

State of California

California Natural Resources Agency

Memorandum

Date: January 31, 2014

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From: **Department of Water Resources**

Subject: Memorandum Report – Site Characterization and Groundwater Monitoring Data Analysis Summary, Prospect Island Tidal Habitat Restoration Project, Solano County, California

I am pleased to present the attached Memorandum Report – Site Characterization and Groundwater Monitoring Data Analysis Summary - Prospect Island Tidal Habitat Restoration Project - Solano County, California for your information and use. This memorandum report presents, in general, the following: executive summary; the purpose of the site characterization and groundwater monitoring study; summary of additional data collection, information research, and geologic and hydrologic data analysis; findings; and recommendations. This study has been ongoing since January 2010 and DWR field activities were performed in cooperation with Reclamation District 501 and Ryer Island landowners.

If you have any questions regarding the project or memorandum report, please contact me at (916) 376-9657.

Attachment

SURNAME
DWR 155 (Rev 7/11)

C.L. Bonds 1/31/14 1/31/14 1-31-14

Site Characterization and Groundwater Monitoring

Data Analysis Summary

Prospect Island Tidal Habitat Restoration Project

Solano County, California

Memorandum Report – January 2014

This memorandum report has been prepared by the following Professional Geologists who were in responsible charge of the work, in accordance with the provisions of the Geologist and Geophysicist Act of the State of California.

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Site Characterization and Groundwater Monitoring Data Analysis Summary, Prospect Island Tidal Habitat Restoration Project, Memorandum Report

January 2014

EXECUTIVE SUMMARY

The Department of Water Resources (DWR) has completed a comprehensive, multi-year study of the geology and groundwater conditions of Prospect Island and adjacent portions of Ryer Island in support of the Prospect Island Tidal Habitat Restoration Project (Project). The purpose of the study was to better characterize the subsurface hydrogeologic conditions in the study area and further evaluate the potential for seepage to occur on Ryer Island as a result of the Project. This study was performed in cooperation with Reclamation District 501 (RD 501) and Ryer Island landowners. Data collection for this study began in January 2010 and included two phases:

Phase 1 - Review of previous studies, subsurface exploration, well installation, groundwater and surface water level monitoring, land and bathymetry surveying, bed sediment sampling, and data reporting.

Phase 2 – additional data collection, creation of a project-specific three dimensional (3D) geographic information system, geologic and hydrologic data analysis, seepage modeling, and final reporting. Baseline hydrologic data collection is ongoing.

The most significant findings and recommendations from this study are presented below.

OVERVIEW OF PROSPECT ISLAND FLOODING, OWNERSHIP, AND LEGAL INFORMATION, AND RYER ISLAND SEEPAGE HISTORY

- Prospect Island is part of the Yolo Bypass and has restricted height levees. It serves as an overflow basin for this portion of the Yolo Bypass, and as a result, during high-flow events, Prospect Island typically floods first and more frequently than surrounding islands. Prospect Island has flooded 13 times since 1919.

- From May 1963 through January 1995, Prospect Island was owned by Sakata Brothers Inc. and during that time period, Prospect Island flooded four times. In that 32 year time period, it is unknown if any complaints were filed by Ryer Island entities against Sakata Brothers Inc. alleging that flooding of Prospect Island was causing seepage impacts on Ryer Island. Prospect Island was transferred from Sakata Brothers Inc. to the Trust for Public Land and then to the US Bureau of Reclamation

(USBR) on January 3, 1995. DWR acquired the northern 1,300 acre portion of Prospect Island from the federal government in January 2010.

- In 1996, Islands, Inc. filed a complaint against USBR for crop damage allegedly caused by subsurface movement of groundwater from Prospect Island to Ryer Island. On August 26, 1996, Sam Sakata Farms filed a complaint for damages alleging that hydrologic pressure from flooded conditions on Prospect Island had resulted in flooding on Ryer Island. On September 3, 1999, RD 501 and Islands, Inc. filed a complaint against the US Army Corps of Engineers and DWR claiming that the Prospect Island Ecosystem Restoration Project environmental document was inadequate and the decision to leave Prospect Island in a submerged state caused and continues to cause seepage under land owned by Islands, Inc. and for which RD 501 has reclamation responsibility. Furthermore, they claimed that the seepage prevented the overlying farmland from growing crops which have historically been grown and caused farm equipment to become mired in the saturated soil. It is unknown what the end result was of this complaint. Also, it is unknown if any additional complaints were filed by Ryer Island entities since 1999.

- Seepage on Ryer Island, and throughout the Sacramento – San Joaquin Delta (Delta), from surrounding sloughs is an ongoing issue that was first documented in DWR Bulletin 125 – Sacramento Valley Seepage Investigation.

- DWR Bulletin 125 documented extensive seepage on Ryer Island from Miner Slough following a high-flow event in 1963 (Prospect Island flooded) and a high-flow event in 1964-65 (Prospect Island did not flood). However, both high-flow events resulted in significant and similar areas of mapped seepage on Ryer Island. It seems likely that extensive seepage occurred on Ryer Island during the four high-flow events that caused Prospect Island to flood between May 1963 and January 1995; a time period in which Prospect Island was owned, operated, and maintained by a private party, Sakata Brothers, Inc. It is unknown if any reports of seepage on Ryer Island were made by landowners following the four high-flow events between 1963 and 1995 when Prospect Island flooded.

- In 2010, DWR-North Central Region Office staff obtained a map from RD 501 that identified areas where the seepage problems occur and in general, the reported seepage areas from RD 501 in 2010 are coincident with the mapped areas of seepage from DWR Bulletin 125.

- The spatial and temporal extents of the RD 501 reported seepage areas are not well defined.

GEOLOGIC AND GEOMORPHIC SETTING

- The majority of the Ryer Island land surface is well below (approximately 5 feet) the average water surface elevation of Miner Slough. This creates seepage pressure from Miner slough toward Ryer Island.
- The RD 501 drainage system artificially lowers groundwater levels (typically 2-3 feet below ground surface). The artificial lowering of groundwater levels further increases the seepage pressure from Miner Slough toward Ryer Island.
- The island interiors have been impacted by agricultural practices, such as aeration, decomposition, compaction, burning, and erosion. Extensive draining of the organic and peaty deposits for agriculture has altered much of the original surficial geologic and geomorphic character and resulted in subsidence on Prospect and Ryer Islands. Subsidence increases the hydraulic gradient from the surrounding sloughs to Prospect and Ryer Islands.
- A levee underseepage evaluation was performed as part of a larger regional levee investigation and the following key finding was made; approximately 90% of recorded underseepage-related performance problems in the Sacramento Valley and Delta occur along levees designated as having high and very high underseepage susceptibility. Of the 15 miles of levee evaluated within this study area, 14.3 miles (96%) had high to very high underseepage susceptibility.

SITE CHARACTERIZATION AND DEVELOPMENT OF HYDROGEOLOGIC CONCEPTUAL MODEL

- Four hydrogeologic units (HU) were defined based on the 3D lithologic model; Levee, Upper Clay, Main Sand, Lower Clay.
- The Upper Clay HU on average is thinner under Ryer Island and thicker under Prospect Island (16 feet - Ryer, 25 feet - Prospect). There appears to be a correlation between the RD 501 reported seepage areas with locations of thin clay (less than 15 feet). Also, the presence of surface drainage ditches further reduce the thickness of the clay in these areas. It was concluded in the Delta Risk Management Study that clay blanket thicknesses of 15 feet or less have the largest impacts on underseepage and the presence of drainage ditches excavated into thin clay blankets significantly increases underseepage.
- Based on the 3D lithologic model, bathymetry, and bed sediment sample data, the channel bottoms of Miner Slough and Sacramento River Deep Water Ship Channel (DWSC) are physically connected to the Main Sand HU throughout the study area.

The intersections of the channel bottom and the Main Sand HU provide pathways for surface water to flow into the groundwater system. In general, these intersections in Miner Slough are adjacent to the RD 501 reported seepage areas.

- Based on the 3D lithologic model, geology and geomorphic maps, and trench logs, the surface of Prospect Island is not connected to the Main Sand HU.
- The integrity of the Upper Clay HU beneath Prospect Island is very important as it acts as a physical and hydraulic barrier. Any restoration design should take this into account.

EVALUATION OF HYDRAULIC CONDUCTIVITY

- The estimated hydraulic conductivity values obtained from this study compare favorably to those reported in other recent Delta studies.

SURFACE WATER AND GROUNDWATER DATA ANALYSIS

- The data indicate that there is a significant hydraulic connection between the DWSC, Miner Slough, and the Main Sand HU due to the physical connection between the channel bottoms of DWSC and Miner Slough and the Main Sand HU.
- Based on the 3D lithologic model, bathymetry, bed sediment samples, and hydrograph data, the channel bottoms of Miner Slough and DWSC are physically and hydraulically connected to the Main Sand HU throughout the study area. The intersections of the channel bottom and the Main Sand HU provide pathways for surface water to flow into the groundwater system. In general, these intersections in Miner Slough are adjacent to the RD 501 reported seepage areas.
- Potentiometric surface contour maps for the summer and winter 2012 periods indicate that Miner Slough is the dominant hydrologic feature controlling groundwater flow within the study area.
- Groundwater levels indicate that surface water from Miner Slough enters the Main Sand HU and flows east beneath and to the surface of Ryer Island.
- Groundwater levels on Ryer Island are significantly influenced by local precipitation and stage in Miner Slough.
- During the winter and early spring, groundwater levels are close to or above the ground surface elevation on Ryer Island. These conditions coincide with precipitation events, stage increases in Miner Slough, and potentially the seasonal change in drainage system operation (which needs to be further evaluated). This is significant

because when groundwater levels in the shallow aquifer system rise to within a foot or less from the ground surface, agricultural activities may be affected due to the saturation of shallow-depth, clay-rich soils. Also, when groundwater levels in the shallow aquifer system rise above the ground surface, groundwater seepage occurs. Furthermore, when the shallow groundwater levels are close to or above the ground surface, any precipitation that occurs will result in ponding.

- During the spring and summer, the groundwater levels on Ryer Island decrease up to several feet and this is likely due to the operation of the Ryer Island drainage system which lowers shallow groundwater levels in order to create a seasonal unsaturated zone to grow crops.

SEEPAGE ANALYSES

- Regardless of the conditions on Prospect Island (dry or flooded) the total head and groundwater flow under the Ryer Island levee show little to no change. Therefore, the Project should have little to no seepage effects on Ryer Island.

RECOMMENDATIONS

- Data collection at Ryer Island monitoring wells MW 99-9 and -10 was discontinued on February 2012 at the request of the land owner. This caused a hydrologic data gap in the northwest portion of Ryer Island. Reestablishment of monitoring wells in this area would be beneficial.

- Further exploration of the connection between the Miner Slough channel bottom and the subsurface hydrogeology may be useful.

- Operation of the RD 501 drainage system affects shallow groundwater levels on Ryer Island. The standard operating procedures of the drainage system need to be further evaluated.

- The existing monitoring well network on Prospect and Ryer Island should be monitored consistently throughout all future phases of the Project.

- The spatial and temporal extents of the RD 501 reported seepage areas need to be better defined.

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Cover Photo: View of Prospect Island looking northwest near CPT site PI-1

ABBREVIATIONS AND ACRONYMS

3D	three dimensional
ABS	acrylonitrile butadiene styrene
bgs	below ground surface
CPT	Cone Penetration Test
CPTu	Piezocone
Delta	Sacramento-San Joaquin Delta
DEM	Digital Elevation Model
DWR	California Department of Water Resources
DWSC	Sacramento River Deep Water Ship Channel
FWLA	Fugro William Lettis & Associates
GIS	Geographic Information System
GM	geometric mean
gpm	gallons per minute
HU	hydrogeologic units
K	Hydraulic conductivity
K_{ppdt}	Hydraulic conductivity estimated from pore pressure dissipation testing
K_{sbt}	Hydraulic conductivity estimated from soil behavior type
K_{st}	Hydraulic conductivity estimated from slug testing
NAVD88	North American Vertical Datum 1988
NCRO	North Central Region Office
PPDT	Pore Pressure Dissipation Test
Project	Prospect Island Tidal Habitat Restoration Project
RD 501	Reclamation District 501
SBTn	normalized soil behavior type
USACE	US Army Corps of Engineers
USBR	US Bureau of Reclamation
USCS	Unified Soil Classification System

1.0 OVERVIEW OF SITE CHARACTERIZATION AND GROUNDWATER MONITORING STUDY

The purpose of this study was to; 1) characterize the subsurface hydrogeologic conditions, 2) evaluate the past and current seepage conditions in the Prospect and Ryer Island study area, and 3) evaluate the potential for seepage to occur on Ryer Island as a result of the Prospect Island Tidal Habitat Restoration Project (Project). This study was designed to collect a more comprehensive data set than was collected during previous restoration efforts. Furthermore, the additional data collection, monitoring, and analysis efforts performed for this study are intended to address the previous concerns and data deficiencies raised by Reclamation District 501 (RD 501) and Ryer Island landowners.

The term seepage is frequently used in more than one sense. In its broadest meaning, and as most commonly applied, seepage is used to describe a high groundwater table and any surface water which result in part from percolation from river channels and in part from local rainfall and runoff. Seepage has also been used in a more restricted sense to describe the water which results from percolation through or under levees, appearing as surface water or groundwater within the root zone on lands adjacent to the levees. For this study, “seepage” is defined in the more restrictive sense.

The study was accomplished in two phases over the course of several years including:

> Phase 1 - Review of previous studies, subsurface exploration, well installation, groundwater and surface water level monitoring, land and bathymetry surveying, bed sediment sampling, and data reporting (DWR, 2013).
>
> Phase 2 – additional data collection, creation of a project-specific three dimensional (3D) geographic information system (GIS), geologic and hydrologic data analysis, seepage modeling, and final reporting. This memorandum report completes Phase 2 of this study.

2.0 PURPOSE OF DATA ANALYSIS REPORT

The purpose of this memorandum report is to analyze the project-specific geology, groundwater, and related technical data collected by the California Department of Water Resources (DWR) since 2010 and make connections (where appropriate) to previous studies. DWR published a data collection summary report in June 2013 (DWR, 2013) which documented data collection through May 2013; however, additional data collection was performed since May 2013 and that data collection and analysis is included in this report.

3.0 ADDITIONAL DATA COLLECTION

The additional data collection included continued groundwater and surface water level monitoring, drainage ditch level monitoring, slug testing, and geomorphologic mapping.

A summary of this data collection is presented below:

3.1 Geomorphologic Mapping and Analysis

In September and October 2013, geomorphologic mapping and analysis of Prospect Island and portions of Ryer Island were performed by a DWR contractor. Refer to Section 6 for details.

3.2 Slug Testing

In July and August 2013, slug testing of 15 wells on Prospect and Ryer Islands was performed. The slug testing data collection, analysis, and results are included in this report. Refer to Section 10 for details.

3.3 Continued Groundwater and Surface Water Level Monitoring

Groundwater and surface water level monitoring from the existing network of 29 wells and three surface water stations is ongoing. Hydrographs included in this report have been extended from June 1, 2013 to October 1, 2013. Refer to Section 11 for details.

3.4 Drainage Ditch Level Monitoring

In July 2013, three new water level monitoring stations along select Ryer Island drainage ditches were established. The period of record extends from July 25 to October 1, 2013. Refer to Section 11 for details.

4.0 LOCATION

Prospect Island is a 1,600-acre property located in Solano County, in the Cache Slough Complex of the northwestern Sacramento-San Joaquin Delta (Delta) (**Figure 4-1**). The island is comprised of two parcels: the northern 1,300-acre portion is owned by DWR and the southern 300-acre portion is owned by the Port of West Sacramento. Prospect Island is situated between the Sacramento River Deep Water Ship Channel (DWSC) to the west and Miner Slough on the east. Liberty Island, a 4,500-acre naturally-breached island that is restoring to tidal marsh and open water, sits just west across the DWSC. Ryer Island, a large agricultural tract, lies to the east across Miner Slough. To the north is the Clarksburg Agricultural District and to the south is Cache Slough. Prospect Island is still designated as part of the Yolo Bypass, although it was cut off from the main Yolo Bypass with construction of the DWSC in 1963.

5.0 OVERVIEW OF PROSPECT ISLAND FLOODING, OWNERSHIP, AND LEGAL INFORMATION, AND RYER ISLAND SEEPAGE HISTORY

5.1 Prospect Island Flooding History

Prospect Island is part of the Yolo Bypass and has restricted height levees. It serves as an overflow basin for this portion of the Yolo Bypass, and as a result, during high-flow events, Prospect Island typically floods first and more frequently than surrounding islands.

Prospect Island has a significant history of flooding dating back to the early 1900s (Hopf, 2011 and URS, 2009). It is reported that Prospect Island has flooded 13 times since 1919 (Hopf, 2011). Since 1962, Prospect Island has flooded at least seven times in the following years: 1963, 1980, 1981, 1983, 1986, 1995, and 1997 (**Table 5-1**). Please note that there were three discrepancies between the two flood history references used in this report. Hopf (2011) reported flood events in 1962 and 2006 that were not reported in URS (2009). URS (2009) reported a flood event in 1982 that was not reported in Hopf (2011). Due to the noted discrepancies, these three flood event years were not included in the above chronology.

5.2 Prospect Island Ownership History

From May 1963 through January 1995, Prospect Island was owned by Sakata Brothers Inc. and during that time period, Prospect Island flooded at least four times (**Table 5-1**). In that 32 year time period, it is unknown if any complaints were filed by Ryer Island entities against Sakata Brothers Inc. alleging that flooding of Prospect Island was causing seepage impacts on Ryer Island. Prospect Island was transferred from Sakata Brothers Inc. to the Trust for Public Land and then to the US Bureau of Reclamation (USBR) on January 3, 1995. DWR acquired the northern 1,300 acre portion of Prospect Island from the federal government through the Public Benefit Conveyance process in January 2010.

5.3 Prospect Island Legal Information

Following the March 1995 flood event, Slater Farms Inc. (a Prospect Island lessee) filed a complaint against USBR for flood losses incurred for 1995 site preparation and lost profits in 1996 and 1997 (**Table 5-1**). USBR repaired the levee and pumped out the island in March-November 1996 and settled the case in August 1996 for about $400,000 (USACE, 2001).

In 1996, Islands, Inc. filed a complaint against USBR for crop damage allegedly caused by subsurface movement of groundwater from Prospect Island to Ryer Island (Leagle.com, 2012) (**Table 5-1**). On August 26, 1996, Sam Sakata Farms filed a complaint for damages alleging that hydrologic pressure from flooded conditions on Prospect Island had resulted in flooding on Ryer Island (Todd, 1998). In 1999, the Islands, Inc. complaint was dismissed due to federal government immunity from suit under the Flood Control Act (Leagle.com, 2012). It is unknown what the end result was of the Sam Sakata Farms complaint.

On September 3, 1999, RD 501 and Islands, Inc. filed a complaint against the US Army Corps of Engineers (USACE) and DWR claiming that the Prospect Island Ecosystem Restoration Project environmental document was inadequate and the decision to leave Prospect Island in a submerged state caused and continues to cause seepage under land owned by Islands, Inc. and for which RD 501 has reclamation responsibility (RD 501 and Islands, Inc., 1999) (**Table 5-1**). Furthermore, they claimed that the seepage prevented the overlying farmland from growing crops which have historically been grown and caused farm equipment to become mired in the saturated soil. It is unknown what the end result was of this complaint. Also, it is unknown if any additional complaints were filed by Ryer Island entities since 1999.

5.4 Ryer Island Seepage History

In the Delta, seepage is a regional problem because much of the land surface is below sea level (Priestaf, 1983; URS, 2009). The Ryer Island portion of the study area has land surface elevations that range from slightly above sea level to more than 5 feet below sea level, excluding the levees.

Bulletin 125 (DWR, 1967) documented that extensive seepage extended 1,000 feet or more into the interior of Ryer Island from Miner Slough following two high-flow events in 1963 and 1964-65 (**Figure 5-1**). It was reported that Prospect Island flooded during the 1963 event, but not during the 1964-65 event. However, both high-flow events resulted in significant and similar areas of mapped seepage on Ryer Island that extended beyond the Miner Slough levee and well into the island's interior (with and without the flooding of Prospect Island).

GEI (1999) reported that signs of increased seepage on Ryer Island were observed by landowners to coincide with the flooding of Prospect Island in 1996.

The signs of increased seepage included:

- Wetter ground that did not support farming equipment after years and decades of not observing similar conditions when Prospect Island was not partly flooded
- Poor crop yields or dying crops due to higher moisture conditions
- Need for additional dewatering ditches in areas where the number and spacing of ditches had not changed for decades

Considering the significant seepage reported on Ryer Island in Bulletin 125 with flooding (1963) and without flooding (1964-65) on Prospect Island, it seems likely that extensive seepage occurred on Ryer Island during the four high-flow events that caused Prospect Island to flood between May 1963 and January 1995; a time period in which Prospect Island was owned, operated, and maintained by a private party, Sakata Brothers, Inc.

However, it is unknown if any reports of increased seepage problems on Ryer Island were made by landowners following the four preceding high-flow events between 1963 and 1995 when Prospect Island flooded.

On January 5, 2010, DWR-North Central Region Office (NCRO) staff made their first visit to Ryer Island with DWR-Division of Environmental Services staff and Ryer Island stakeholders. During this visit, DWR obtained valuable information from the stakeholders about past and present Ryer Island conditions. The most significant information reported was that seepage conditions in some areas of Ryer Island adjacent to Miner Slough and Prospect Island have significantly impacted agricultural operations. The stakeholders are concerned that DWR's plan to restore Prospect Island to a tidal habitat will exacerbate the seepage problem. NCRO staff obtained a map from Mr. Tom Hester (RD 501) that identified areas where the seepage problems occur and those areas are superimposed on **Figure 5-1** for reference. In general, the reported seepage areas from RD 501 in 2010 are coincident with the mapped areas of seepage from Bulletin 125 (1967). However, the spatial and temporal extents of the RD 501 reported seepage areas are not well defined.

6.0 GEOLOGIC AND GEOMORPHIC SETTING

6.1 Regional Geologic Setting

The Delta area has been shaped by complex tectonic and depositional processes throughout the Quaternary Period (past 2 million years). The present configuration of the Delta, as the outlet of the Central Valley, was established about 600,000 years ago (Sarna-Wojcicki et al., 1985). Since that time, fluctuations in sea level caused by climate variations have contributed to a complex depositional history of alternating fluvial and estuarine environments. During glacial conditions, sea level was low, alluvial plains were exposed, and rivers carrying coarse-grained sediments incised to grade to an ocean level hundreds of feet below present elevation and a coastline several miles west of its present day position (Shlemon, 1967). During interglacial periods (Holocene), sea levels raised, which subsequently filled the San Francisco Bay and Delta with alluvial, deltaic, and estuarine sedimentary deposits.

About 15,000 years ago at the close of the last glacial period, sea level began to rise as glaciers began to recede. Subsequent vertical changes and an eastward-transgression in sea level in the San Francisco Bay area are recorded by tidal-marsh deposits located at the base of Holocene estuarine sediments (Atwater et al., 1977; Atwater, 1980). The local geologic record of Holocene sea-level changes indicates that the rising sea entered the San Francisco Bay area 10,000 to 11,000 years ago (Helley et al., 1979). The newly formed bay spread across land areas as rapidly as 100 feet per year. The ocean reached its present level about 6,000 years ago (Helley et al., 1979). As sea level rose throughout the early Holocene, the base levels of the streams in the bay region were raised slightly, the younger alluvial sediments were deposited on flood plains around the growing bay, and the younger bay mud was deposited beneath the rising water. Delta inundation rates decreased substantially since about 6,000 years ago (Malamoud-Roam et al., 2007), such that the pace of sea-level rise was slow enough to allow tidal marshes and ecosystems to form in close connection with sea level position (URS, 2007). This resulted in Holocene (interglacial) organic clay, silt, and peat that have spread across and over coarser grained latest Pleistocene alluvium. Another result of sea-level rise is silty and clayey Holocene river alluvium that extends into the Delta and overlies the peat and mud as natural levees (Atwater, 1982).

6.2 Geomorphic Setting

The study area lies within the topographically low area of the southwestern Sacramento Valley, between the alluvial fan deposits of the Coast Range to the west, Montezuma Hills to the southwest, and the Sacramento River to the east. The tidally influenced surface water features in the study area include the DWSC on the west and Miner Slough which flows between Prospect Island and Ryer Island. Extensive dredging and channel augmentation of the DWSC and Miner Slough has occurred historically. In general, these activities provided the material that was used to construct the levees in the area (Thompson and Dutra, 1983).

The land surface generally slopes to the south-southeast with elevations ranging from a maximum of approximately 30 feet on top of the Ryer Island levee to greater than 5 feet below sea level in the southern portion of the study area on Ryer Island. The majority of the land surface inside the levees on Prospect Island is near sea level to slightly below sea level and nearly all the land on Ryer Island is below sea level. As documented in GEI (1999), "most of Ryer Island is below water surface elevations in the surrounding rivers, creeks, and sloughs…and…groundwater levels are controlled by a network of dewatering ditches which flow to a low point at the southern end of the island where the water is removed by pumping." The Ryer Island drainage system, that is excavated into the surface layer of organic clay and silt, is used to artificially lower groundwater levels enough (typically 2 to 3 feet below ground surface (bgs) to create an aerobic root zone in order to grow crops. The artificial lowering of groundwater levels increases the hydraulic gradient from Miner Slough toward Ryer Island.

The geomorphic setting of the study area consists of islands separated by fluvial channels and tidal sloughs that, prior to construction of artificial levees and dredge cuts, were directly connected with fluvial and estuarine hydrology and sediment fluxes. The islands are saucer-shaped in cross section, and possess elevated natural levees consisting of silt and loam from overflow of the directly-adjacent channels and sloughs. Prior to reclamation, the central part of the islands were covered by organic silts and clays with varying amounts of peat originally formed from decaying vegetation. The island interiors have been impacted by agricultural practices, such as aeration, decomposition, compaction, burning, and erosion. Extensive draining of the organic and peaty deposits for agriculture has altered much of the original surficial geologic and geomorphic character and resulted in subsidence on Prospect and Ryer Islands. Subsidence increases the hydraulic gradient from the surrounding sloughs to Prospect and Ryer Islands.

Surficial deposits on Prospect and Ryer Island are late Holocene, unconsolidated and fine-grained muck (organic-rich silt and clay) with lesser amounts of peat (Atwater, 1982; USACE, 2001a). The percentage of organic material (peat) is highest near the center of the Delta, and decreases in the direction of higher elevations of the delta edge (Atwater, 1982). A quantitative analysis of the distribution of organic material in the Delta, completed by Deverel and Leighton (2010), indicates the majority of the study area has between 0-6% organic material with the southern portion of the DWR-owned Prospect Island having between 6-11% organic material. This matches well with surface and subsurface data within the study area.

Geomorphic assessment and surficial geologic mapping of Prospect and Ryer Islands were completed as part of the current study. These materials were prepared as an addendum to the Geomorphic Assessment and Surficial Mapping of the West Delta Study Area Technical Memorandum (Fugro William Lettis & Associates (FWLA), 2010) (**Appendix A**).

The surficial geologic mapping and geomorphic assessment provides information on the type and distribution of surface and shallow subsurface deposits that underlie the study area. This information was used to develop a conceptual model that allows reasonable stratigraphic interpretations for characterization of subsurface materials between exploration sites.

The technical approach used to create the 1:24,000-scale map of surficial geology of the study area focused on review and analysis of the following materials:

- 1937 aerial photography
- Early and modern topographic maps
- Published surficial geologic maps (Atwater, 1982; Helley and Harwood, 1985)
- Early and modern soil survey data (Holmes et al., 1913; Natural Resources Conservation Service [NRCS] 2007)

Previous regional geologic mapping in the study area was completed by Atwater (1982) and Helley and Harwood (1985).The new surficial mapping used this regional geologic framework and more recent surficial geologic mapping completed by FWLA (2010) as a basis for more detailed mapping of Quaternary deposits and geomorphic features (**Appendix A**). The surficial geologic units encountered in the study area are summarized below in order of oldest to youngest with the accompanying surface soil unit (Cosby, 1941). A more detailed description of the map units and mapping criteria are in **Appendix A**.

The study area consists of Holocene and historical age deposits. The Holocene deposits underlie the modern floodplain and islands representing pre development (pre-1850) deposition, while the historic deposits represent the active slough and overbank deposits. Freshwater marsh, flood basin, and tidal marsh deposits are similar and transition laterally into each other with increasing organic content from basin to marsh to tidal deposits.

6.2.1 Holocene deposits

Fresh water marsh deposits (Hs) consist of silt and clay with occasional thin organic lenses, deposited in perennially or seasonally submerged, low-lying areas. Marsh deposits are similar in texture to basin deposits, but are mapped based on the 1906 and 1907 topographic maps depicting marsh areas with tule or bulrush vegetation (Vaught, 2006) and the presence of the Sacramento silty clay loam (Cosby, 1941)

Flood basin deposits (Hn) include clay and silty clay with minor amounts of sand deposited by low-energy floodwaters that seasonally inundate the flood basin. The deposit usually does not contain substantial organic material (Helley and Harwood, 1985) and fine-grained materials within this unit may have high plasticity. This unit correlates to the Sacramento silty clay loam (Cosby, 1941).

Peat and muck deposits (Hpm) are tidal marsh deposits that were originally more organic rich and less consolidated than Holocene marsh deposits (map unit Hs). Holocene peat and muck deposits are typically at or below sea level and were typically enclosed by levees and drained for farming before 1937. The thickness of the peat varies and generally is thicker near the center of the Delta and thinner near the margins of the Delta (USACE, 1987). The island interiors have been impacted by aeration, decomposition, compaction, burning, and erosion. Because of the extensive draining of the surficial peaty deposits for agriculture, much of the original surficial geologic and geomorphic character of the former tidal wetland has been altered. Therefore, mapping the surficial extent of unit Hpm for this study draws on existing interpretations by Atwater (1982). Within the study area, peat and muck deposits usually coincide with areas mapped as the Egbert silty clay loam and the Ryde clay loam (Cosby, 1941).

Slough deposits (Hsl) traverse the lowest areas of the flood basin near sea level and are tidally influenced. These low-slope and usually low-energy perennial channels carried sandy silts and clays.

Overbank deposits (Hob) and Crevasse splay deposits (Hcs) make up the natural levees that parallel the larger sloughs (Miner and Prospect) and smaller tidal channels in the study area. These deposits consist of varying amounts of silt, clay, and fine sand. Crevasse splay deposits are formed from breaching of artificial or natural levees and the deposition of radiating lobes of material on the floodplain. Overbank deposits are formed from broad overtopping of slough channel banks or natural levees and deposition from shallow sheet flow. These units generally coincide with the Columbia fine sandy loam and the Valdez silt loam (Cosby, 1941).

6.2.2 Historic deposits

Levees (L) consist of artificial fill with mixtures of clay, silt, sand, and gravel typically derived from the adjacent channel, slough, or floodplain and emplaced on the existing land surface.

Historical deposits include crevasse splay and overbank deposits near the active channels (map units Rcs and Rob), and slough deposits (Rch and Rsl). These sediments were deposited by the same geomorphic processes as the older Holocene units.

6.2.3 Levee Underseepage Susceptibility Analysis

Based on the results of the geomorphic assessment, an underseepage susceptibility rating was assigned for the Prospect Island and northwestern Ryer Island levee foundations based on the underlying surficial geologic unit, geologic age, and depositional environment (**Appendix A**). These factors exert controls on levee underseepage processes. This underseepage evaluation was performed as part of a larger regional levee investigation (URS, 2011) with the following key finding, approximately 90% of recorded underseepage-related performance problems in the Sacramento Valley and Delta occur along levees designated as having high to very high underseepage susceptibility ratings. Of the 15 miles of levee evaluated within the study area, 14.3 miles (96%) had high to very high underseepage susceptibility ratings. This key finding further indicates that seepage on Ryer Island is an ongoing problem that is sourced mainly from Miner Slough.

7.0 REGIONAL GROUNDWATER SETTING

The Project is situated within the southeastern portion of the Solano Subbasin of the Sacramento Valley Groundwater Basin (DWR, 2003; Basin Number 5-21.66; **Figure 7-1**). The descriptive information presented in this section was excerpted from Bulletin 118-03 California's Groundwater (DWR, 2003).

7.1 Basin Boundaries and Hydrologic Features

The Solano Subbasin lies in the southwestern portion of the Sacramento Basin and the northern portion of the Delta. The subbasin extends across portions of Solano, Sacramento, and Yolo Counties and has a surface area of 664 square miles. Surface elevations vary from120 feet in the northwest corner to below sea level in the south. Subbasin boundaries are defined by; Putah Creek on the north, the Sacramento River on the East (from Sacramento to Walnut Grove), the North Mokelumne River on the southeast (from Walnut Grove to the San Joaquin River), and the San Joaquin River on the South (from the North Mokelumne River to the Sacramento River. The western subbasin border is defined by the hydrologic divide that separates lands draining to the San Francisco Bay from those draining to the Delta. That divide is roughly delineated by the English Hills and the Montezuma Hills.

Primary waterways in and bordering the subbasin include the Sacramento, Mokelumne and San Joaquin Rivers, the DWSC, and Putah Creek. Annual precipitation averages in the subbasin range from approximately 23 inches in the western portion of the subbasin to 16 inches in the eastern portion.

7.2 Hydrogeologic Information

The primary water-bearing formations comprising the Solano Subbasin are sedimentary continental deposits of Late Tertiary (Pliocene) to Quaternary (Recent) age.Fresh water-bearing units include younger alluvium, older alluvium, and the Tehama Formation (Thomasson et al., 1960). The units pinch out near the Coast Ranges on the west and thicken to a section of nearly 3,000 feet near the eastern margin of the basin. Saline water-bearing sedimentary units underlie the Tehama formation and are generally considered the saline water boundary (adapted from Thomasson et al.,1960).

Flood basin deposits occur along the eastern margin of the subbasin. These deposits consist primarily of silts and clays, and may be locally interbedded with stream channel deposits of the Sacramento River. In the delta, flood basin deposits contain a significant percentage of organic material (peat), and are sometimes mapped as peaty mud (Wagner et al.,1987). Thickness of the unit ranges from 0 to 150 feet. The flood basin deposits have low permeability and generally yield small quantities of water to wells. Recent stream channel deposits consist of unconsolidated silt, fine- to medium-grained sand, gravel and in some cases cobbles deposited in and adjacent to active streams in the subbasin. They occur along the Sacramento, Mokelumne and San Joaquin Rivers, and the upper reaches of Putah Creek. Thickness of the younger alluvium ranges from 0 to 40 feet, however with the exception of the Delta, they generally lie above the saturated zone.

Older alluvium consists of loose to moderately compacted silt, silty clay, sand, and gravel deposited in alluvial fans during the Pliocene and Pleistocene. Thickness of the unit ranges from 60 to 130 feet, about one quarter of which is coarse sand and gravel generally found as lenses within finer sands, silts, and clays. Permeability of the older alluvium is highly variable. Wells penetrating sand and gravel lenses of the unit produce between 300 and 1000 gallons per minute (gpm). Adjacent to the Sacramento River, wells completed in ancestral Sacramento River stream channel deposits yield up to 4,000 gpm. Wells completed in the finer-grained portions of the older alluvium produce between 50 and 150 gpm.

The Tehama Formation is the thickest water-bearing unit underlying the Solano Subbasin, ranging in thickness from 1,500 to 2,500 feet. Surface exposures of the Tehama Formation are limited mainly to the English Hills along the western margin of the subbasin. It consists of moderately compacted silt, clay, and silty fine sand enclosing lenses of sand and gravel, silt and gravel, and cemented conglomerate. Permeability of the Tehama Formation is variable, but generally less than the overlying younger units. Because of its relatively greater thickness, however, wells completed in the Tehama can yield up to several thousand gpm.

Underlying the Tehama Formation are brackish to saline water-bearing sedimentary units including the somewhat brackish sedimentary rocks of volcanic origin (Pliocene to Oligocene) underlain by undifferentiated marine sedimentary rocks (Oligocene to Paleocene). These units are typically of low permeability and contain connate water. The upper contact of these units generally coincides with the fresh/saline water boundary at depths as shallow as a few hundred feet near the Coast Range on the west to nearly 3,000 feet near the eastern margin of the subbasin (Berkstresser et al.,1973).

7.3 Groundwater Levels and Flow

Groundwater levels were measured at what we now consider to be natural, predevelopment levels in 1912 by the US Geological Survey (Bryan, 1923). At that time, the general direction of groundwater flow in the subbasin was from northwest to southeast.

During the spring of 2012, regional groundwater levels in the vicinity of the Project were between 5 and -5 feet mean sea level and flow was generally from the northwest to the southeast (**Figure 7-2**) similar to predevelopment conditions.

8.0 SITE CHARACTERIZATION AND DEVELOPMENT OF HYDROGEOLOGIC CONCEPTUAL MODEL

8.1 Introduction

The subsurface interpretations of previous studies related to the Project (Todd, 1998; GEI, 1999) were based on limited subsurface information from a small number of shallow (less than 40 feet) boreholes. Since these earlier studies took place, a substantial amount of new information has been collected. (Kleinfelder, 2007; ENGEO, 2012; DWR, 2013). This study integrates the existing datasets with this new information to define the subsurface lithologic and hydrogeologic heterogeneity within the study area. A 3D model of lithologic variations within the study area was developed by extrapolating data away from boreholes using a 3D gridding process (Rockware Earth

Science and ESRI GIS software: www.rockware.com, www.esri.com). Subsurface hydrogeology is defined through the identification of distinctive lithologic packages, tied to high-quality well control. Available subsurface data provided sufficient detail within these units to develop a reliable subsurface geologic model. This 3D lithologic model provides a better understanding of the thickness, extent, and distribution of subsurface hydrogeologic units and how those units might affect the flow of surface water and groundwater.

8.2 Compilation of Surface and Subsurface Data

Construction of the lithologic and subsequent hydrogeologic framework model integrated data from multiple sources to define the subsurface distribution and extent of each lithologic and hydrogeologic unit. Input data sources included a digital elevation model (DEM), bathymetry data, geologic and geomorphic maps, and lithologic information interpreted from geotechnical borehole and cone penetration test (CPT) data. The following is a description of each input dataset:

8.3 Surface Geologic, Geomorphic, and Topographic Map Data

Previous regional geologic mapping in the study area was completed by Atwater (1982) and Helley and Harwood (1985). New surficial mapping (**Appendix A**) used this regional geologic framework and more recent surficial geologic mapping completed by (FWLA, 2010) as a basis for more detailed mapping of Quaternary deposits and geomorphic features. This information was used to develop a conceptual model that allows reasonable stratigraphic interpretations for characterization of subsurface materials between explorations sites.

Topographic and bathymetric data (**Figure 8-1; Appendix B**) were combined to create a one meter DEM for the study area. This DEM was used to constrain the top of the lithologic model and was valuable in estimating the connection of the Miner Slough and DWSC bottoms to the subsurface hydrogeologic units.

8.4 Subsurface Data

8.4.1 CPT Soil Behavior Type and Soil Samples

The primary dataset used to construct the 3D lithologic model were 18 CPT soundings collected on Prospect and Ryer Islands in 2011 and 2012 (DWR, 2013). The CPT's were used to delineate soil stratigraphy and estimate geotechnical engineering properties in the study area. The stratigraphic interpretation, referred to as the normalized soil behavior type (SBTn), is based on the cone resistance (q_t), sleeve friction (f_s), and pore pressure (u) data recorded, every 2 inches (5 cm), during the CPT.

The SBTn data from the 18 soundings were classified into nine lithologic types (**Table 8-1**). To verify the SBTn data were accurately representing the subsurface lithology, 63 soil samples were collected and described using the Unified Soil Classification System (USCS) (DWR, 2013) and the SBTn data were qualitatively compared to the soil samples in this report. Refer to Section 9 for details.

8.4.2 Geotechnical borehole and Trench data

Subsurface data from 26 existing geotechnical boreholes were used to enhance the 3D lithologic model (**Figure 8-2**). This dataset consisted of high quality analysis of core samples using the USCS (ASTM D-2488) soil classification and subsequent laboratory testing. In addition to the geotechnical boring data, 25 trenches were excavated and four borings were hand augered on Prospect Island to depths ranging from 5 to 10 feet bgs (**Figure 8-2**). The trenches were logged according to USCS (ASTM D-2488) standards and groundwater observations were documented (**Appendix C**). In order to standardize the lithology types in the model, the geotechnical boring and trench data were assigned an SBTn equivalent and entered into the subsurface database. A correlation table of the SBTn types and the equivalent USCS classifications was created (**Table 8-1; Appendix D**).

8.5 3D Modeling Results

8.5.1 3D Lithologic Model

All subsurface soil descriptions were simplified into nine lithologic types (**Table 8-1**). The standardized subsurface lithologic data were then used to construct a 3D lithologic model of the study area (**Figure 8-3**). Interpreted drill-hole lithologic data were numerically interpolated between drill holes by using a cell-based, 3D gridding process using the RockWorks 15, 3D modeling software package (Rockware Earth Science and GIS software: www.rockware.com). In this method, a solid modeling algorithm is used to extrapolate numeric codes that represent lithologic types. Grid nodes between drill holes are assigned a value that corresponds to a lithologic type based on the relative proximity of each grid node to surrounding drill holes. The interpolation routine looks outward horizontally from each drill hole in search circles of increasing diameter. Initially, the algorithm assigns a lithology type to grid nodes immediately adjacent to each drill hole, at a vertical discretization of 1 foot. Then, the interpolation moves outward from the drill hole by one node and assigns the next circle of grid nodes a lithology type. The interpolation continues in this manner until the program finds a cell that is already assigned a lithology type (presumably interpolating toward it from an adjacent drill hole), in which case it skips the node assignment step. A strength of the 3D gridding process is that the interpolated data in the resulting 3D grid have the appearance of stratigraphic units, with aspect ratios that emphasize the horizontal dimension over the vertical (**Figures 8-4 through 8-7**). Also, the method preserves the local variability of the lithology in each drill hole with no smoothing or averaging. Thus, where data are abundant, local lithologic variability is incorporated. One limitation of this type of numerical interpolation is the sensitivity to the distribution of the data, where values from an isolated drill hole tend to extrapolate outward to fill a large amount of the model area.

Cell dimensions for the 3D interpolation were 30 feet in the horizontal dimensions and 1 foot in the vertical dimension. The vertical discretization was chosen as a compromise between preserving lithologic detail, such that thin lithologic units are not averaged out, and computational efficiency, such that model runs could be completed in a reasonable time. The model ranges in elevation (NAVD88) from 30 feet to -100 feet, for a total thickness of 130 feet. The 3D lithologic model was trimmed at the top using a one meter DEM, that was resampled to match the 30 x 30 foot model grid spacing, to represent the land surface on both Prospect and Ryer islands and bathymetry elevations of Miner Slough and DWSC and the base was defined by the maximum total depth of the exploration data (100 feet NAVD88, RI-3 CPT).

For the 3D lithologic model presented here, strata were assumed to be horizontal. The assumption of horizontality is likely valid because of the young age (Holocene) of the sediments in the study area. The 3D lithologic model interpolation was tested by comparing the mapped surface geology to that predicted at land surface by the 3D model. The density of drill-hole lithologic data is greatest at the surface, so resolution of the 3D model should be highest near the surface. When the solid lithologic model is trimmed with the DEM and bathymetry (**Figure 8-10**), the resulting upper model surface compares well to the geologic and geomorphic maps (**Appendix A**) and bed sediment samples (**Table 8-2; Figures 8-8 through 8-10**). Refer to Section 10 for a detailed description of the bed sediment sample analysis. Examples of general agreement between the modeled surface and the geologic and geomorphic maps are; 1) the distribution of fine-grained sediment (silt and clay) on the interior of Prospect and Ryer Islands and the mapped distribution of Peat and Muck (Hpm), Basin deposits (Hn), and Marsh deposits (Hs); 2) the presence of sand in the deep scours and thalweg of Miner Slough and DWSC with the bed sediment samples from the sloughs (**Figure 8-9**); and 3) the sand and silty sand dominated levees surrounding both Prospect and Ryer Islands (**Figure 8-10**).

8.6 3D Hydrogeologic Units

Based on the 3D lithologic model, four hydrogeologic units (HU) were delineated: Levee, Upper Clay, Main Sand, and Lower Clay. The Lower Clay HU was observed below the Main Sand HU; however, this HU was not delineated to the same extent as the other three HUs because the lower extent of this unit could not be determined. The identification of HUs was important to assess lithologic factors that could affect hydraulic properties of the aquifer system for characterization of groundwater flow and as inputs to the seepage model. It was clear that each of the HUs had a distinct mappable character in the subsurface as a function of SBTn lithology types. The Levee HU is a mixture of all SBTn lithology types due to the variable nature of emplacement; the Upper Clay HU is generally comprised of SBTn lithology types 1, 2, 3, and 4; and the Main Sand HU generally includes SBTn lithology types 5, 6, and 7. In terms of soil behavior, the boundary between sand-like and silt/clay-like material is often assumed to be between SBTn zones 4 and 5 (**Figure 8-11;** Robertson, 2010; P. Robertson, personal communication, December 16, 2013). Due to the lack of detailed data on the age of each unit, the assignment of stratigraphic tops was lithology based and did not rely on the specific ages. Mappable lithologic sequences were identified in the well data by analyzing numerous cross sections across the study area (**Figures 8-4 through 8-7**) and making hydrogeologic interpretation based on SBTn lithology type and hydraulic conductivity data. The upper and lower contacts of the Upper Clay and the Main Sand HUs were determined interactively by viewing numerous cross sections and the lithologic logs (**Appendix D:** GEI, 1999) to maximize the consistency of the hydrogeologic interpretation.

The 3D hydrogeologic framework of the study area was constructed by standard subsurface mapping methods of creating structure contour maps (**Figures 8-12 and 8-13**) for the upper (surface topography) and lower surface of the Upper Clay and the Main Sand HUs. The thickness (isopach) of these two HUs were calculated by subtracting the upper surface elevation from the lower surface elevation (**Figures 8-14 and 8-15**). The structural elevation of stratigraphic tops and thickness of each HU was contoured, on a 5 foot interval, to display the variation in thickness and extent.

8.6.1 Hydrogeologic Units

8.6.1.1 Levee

The Levee HU throughout the study area consists of predominantly recent (post 1850's) artificial fill with mixtures of clay, silt, sand, and gravel typically derived from the adjacent channel, slough, or floodplain and emplaced on the existing floodplain and/or slightly elevated deposits of Miner Slough's natural levees which consist of sheets of crevasse splay and overbank deposits (**Appendix A**). The average thickness of this HU is approximately 14 feet on Prospect Island and 25 feet on Ryer Island. The hydraulic conductivity of the Levee HU is described in Section 10. The Levee HU overlies the Upper Clay HU along Miner Slough and the DWSC.

8.6.1.2 Upper Clay

The Upper Clay HU consists of soft to stiff, low- to high-plasticity clay with a minor amount of clayey silt and silty sand deposited in floodplain, flood basin and tidal marsh environments within the northwestern portion of the Delta (DWR, 2013; **Appendix A and D**). The Upper Clay HU also contains varying amounts of organic material that increases in the southern portion of Prospect Island and the south-southeastern portion of Ryer Island, which corresponds to lower surface elevations and historic inundation by flood waters and tidal influence and the deposition of Peat and Muck (Hpm) geologic/geomorphic unit (**Appendix A;** Atwater 1982; Deverel and Leighton, 2010). The Upper Clay HU is Holocene in age and is a combination of the active floodplain material mapped as Peat and Muck (Hpm) and is equivalent to the Basin and Peat Deposits and youngest Modesto Formation of Helley and Harwood (1985).

The Upper Clay HU varies in thickness from 7 to 74 feet within the study area and on average is thinner under Ryer Island (16 feet) and thicker under Prospect Island (25 feet) (**Figure 8-14; Table 8-3**). There appears to be a correlation between the RD 501 reported seepage areas with locations of thin clay (less than 15 feet) and the presence of surface drainage ditches that further reduce the thickness of the clay in these areas. This is consistent with the URS (2009) Section 7, Flood Risk Analysis that found, through modeling, that clay blanket thicknesses of 15 feet or less have the largest impacts on underseepage. Additionally, the presence of drainage ditches excavated into thin clay blankets significantly increases underseepage. The hydraulic conductivity of the Upper Clay HU is described in Section 10. The Upper Clay HU is bound by the Levee HU above (along Miner Slough and DWSC) and below by the Main Sand HU.

8.6.1.3 Main Sand

The Main Sand HU consists of well-sorted fine to medium sand with varying amounts of silt, clay, and fine gravel derived either from broad ancestral river or slough channels and floodplain environments related to the proto-Sacramento River fluvial system or alluvial fans from west and southwest of the study area (Shlemon and Begg, 1975; Atwater, 1982; URS, 2011; DWR, 2013; **Appendix A and D**). Sand grain mineralology within this unit consist of varying mixtures of metamorphic and volcanic rock fragments very similar to those found in the shallow subsurface of the southern Sacramento Valley. Because of the lack of diagnostic mineralology assemblages it is difficult to determine a specific provenance of the sand material and therefore, it is most likely a combination of Coast Ranges and Sierra Nevada sources. The Main Sand HU is Holocene to Late Pleistocene in age and is a combination of the Modesto Formation and the Riverbank Formation of Helley and Harwood (1985).

The Main Sand HU varies in thickness from 8 to 67 feet within the study area and on average is thinner under Prospect Island (35 feet) and thicker under Ryer Island (38 feet) (**Figure 8-15; Table 8-3**). The Main Sand HU thins to the northwest and south with the thickest area, which corresponds to the area closet to the surface, in the central portion of the study area underlying Miner Slough. The hydraulic conductivity of the Main Sand HU is described in Section 10. The Main Sand HU is bound by the Upper Clay HU above and below by the Lower Clay HU.

8.6.1.4 Lower Clay

The Lower Clay HU underlies the Main Sand HU and consists of predominantly clay and silty clay with minor amounts of silty sand. The Lower Clay HU has a variable thickness and was not fully delineated due to the lack of deeper explorations. Wells PI-3C and -9C are screened across a deeper sand interval within the Lower Clay HU.

8.6.2 Relationship of Prospect Island, Miner Slough, and DWSC to Subsurface Hydrogeologic Units

Based on the 3D lithologic model (**Figures 8-4 through 8-7**), bathymetry (**Appendix B**), and bed sediment sample data (**Figure 8-9**), the channel bottoms of Miner Slough and DWSC are physically connected to the Main Sand HU throughout the study area. The intersections of the channel bottom and the Main Sand HU provide pathways for surface water to flow into the groundwater system. In general, these intersections in Miner Slough are adjacent to the RD 501 reported seepage areas (**Figure 8-9**).

Based on the 3D lithologic model (**Figures 8-4 through 8-7)**, geology and geomorphic maps (**Appendix A**), and trench logs (**Appendix C**), the surface of Prospect Island is not connected to the Main Sand HU (**Figure 8-10**).

9.0 SBTn DATA COMPARISON TO SOIL SAMPLES AND RYER ISLAND STRATIGRAPHY

9.1 Comparison of SBTn results to Soil Samples

In September 2011 and March 2012, 63 soil samples were collected on Prospect Island (35) and Ryer Island (28) adjacent to CPT soundings and Ryer Island groundwater monitoring wells. Details of the soil sampling were reported in DWR (2013). Robertson and Cabal (2012) state that it is advisable to obtain samples from appropriate locations to verify the soil behavior type, if no prior CPT experience exists in a given geologic environment. Therefore, a qualitative comparison of SBTn results to adjacent soil samples was performed and the results are as follows:

9.1.1 Prospect Island

Of the 35 soil samples collected, 33 were found to be a good match to the collocated SBTn results (~94%). Poor SBTn matches were found to occur in only two samples (~6%); CPT sounding PI-1 from 15.5-16.5 feet and in CPT sounding PI-3 from 12-13 feet. Sample PI-1 from 15.5-16.5 feet was field described as silty sand (SM) but the SBTn equivalent was estimated to range from silt to clay (ML-CL). Sample PI-3 from 12-13 feet was field described as silty sand (SM) but the SBTn equivalent was estimated to be clay (CL). Both of these samples were collected near the top of the Upper Clay HU which shows significant variability in soil texture as it transitions to the overlying Levee HU; this may explain the reason for the poor match.

9.1.2 Ryer Island

Of the 28 soil samples collected, all were found to be a good match to the collocated SBTn results (100%).

9.2 Summary

Overall, a 97% match was found between SBTn results and adjacent soil samples (based on 61 out of 63 samples). These results are consistent with Robertson and Cabal (2012) who reported that independent studies have shown that the normalized SBTn chart shown in **Figure 8-11** typically has greater than 80% reliability when compared to samples.

9.3 Comparison of SBTn results to Ryer Island Well Boring Stratigraphy

Four CPT soundings (RI-2, -3, -4, and -5) were collocated adjacent to Ryer Island monitoring wells (MW 99-11, -5/6, -3/4, and -7/8), respectively. A qualitative comparison of SBTn results to soil stratigraphy and soil samples was performed. The SBTn results and 10 CPT soil samples displayed moderate to good correlation to soil stratigraphy approximated in the Ryer Island well borings (**Figure 9-1**).

10.0 EVALUATION OF HYDRAULIC CONDUCTIVITY

The parameter hydraulic conductivity (K) was evaluated for each defined hydrogeologic unit (HU) using two independent CPT methods including soil behavior type (K_{sbt}) and pore pressure dissipation testing (K_{ppdt}). Additionally, K of the Main Sand HU was further evaluated using slug testing methods (K_{st}). Lastly, the above K estimates were compared to K estimates obtained from other recent geotechnical projects in the Delta.

10.1 Hydraulic Conductivity Estimated from Soil Behavior Type (K_{sbt})

Hydraulic conductivity (K) was calculated for all CPT soundings at approximately 2-inch (5 cm) depth intervals using the piezocone (CPTu) data presentation and interpretation software CPeT-IT v.1.7.6.42 (Geologismiki, 2007 and Robertson, 2010). Processed depth profiles of K and graphical displays of other CPeT-IT estimated geotechnical parameters are included in **Appendix E**. Estimates were based on the following proposed relationship between K and normalized Soil Behavior Type index, SBTn I_c:

When $1.0 < I_c \leq 3.27$ $K = 10^{(0.952 - 3.04 * Ic)}$ m/s

When $3.27 < I_c < 4.0$ $K = 10^{(-4.52 - 1.37 * Ic)}$ m/s

In order to better understand the data range and center, the evaluation process began by creating summary statistics for K (sample size, minimum, maximum, and geometric mean (GM)) by HU and by well-screen depth interval (**Tables 10-1 and 10-2**). The GM was selected as the most appropriate statistic for estimating the mean value. Prudic (1991) and other investigators have found that K is generally log-normally distributed for a variety of aquifer materials making the GM more meaningful for determining effective hydraulic conductivity than the arithmetic mean.

10.2 K_{sbt} of Hydrogeologic Units

10.2.1 Prospect Island

The Levee K_{sbt} GM ranged from $2x10^{-6}$ cm/s (PI-6) to $1x10^{-4}$ cm/s (PI-10) with an overall GM of $2x10^{-5}$ cm/s (**Table 10-1**). The Upper Clay K_{sbt} GM ranged from $4x10^{-7}$ cm/s (PI-9) to $4x10^{-6}$ cm/s (PI-4) with an overall GM of $1x10^{-6}$ cm/s. The Main Sand K_{sbt} GM ranged from $1x10^{-3}$ cm/s (PI-5) to $1x10^{-2}$ cm/s (PI-8) with an overall GM of $5x10^{-3}$ cm/s.

10.2.2 Ryer Island

The Levee K_{sbt} could only be estimated at one location that penetrated this HU; CPT sounding RI-2. At this site, the Levee K_{sbt} ranged from $1x10^{-7}$ cm/s to $1x10^{-2}$ cm/s with a GM of $3x10^{-5}$ cm/s (**Table 10-1**). The Upper Clay K_{sbt} GM ranged from $5x10^{-7}$ cm/s (RIS-1) to $1x10^{-5}$ cm/s (RI-5) with an overall GM of $2x10^{-6}$ cm/s. The Main Sand K_{sbt} GM ranged from $1x10^{-4}$ cm/s (RI-3) to $1x10^{-2}$ cm/s (RIS-4) with an overall GM of $4x10^{-3}$ cm/s.

10.3 Summary of Prospect and Ryer Island K_{sbt} of Hydrogeologic Units

The overall K_{sbt} GMs for the Levee, Upper Clay, and Main Sand HUs are 2x10^{-5} cm/s, 2x10^{-6} cm/s, and 3x10^{-3} cm/s, respectively (**Table 10-1; Figure 10-1**). **Figure 10-2** suggests that the Main Sand K_{sbt} appears to be lowest near the east central portion of Ryer Island at CPT sounding RI-3 (1x10^{-4} cm/s) and highest near the east central portion of Prospect Island near sounding PI-8B and west central portion of Ryer Island near sounding RI-4 and RIS-4 (1x10^{-2} cm/s). It is important to note that all of the K_{sbt} estimates of the Main Sand HU from the 18 CPT soundings are within an order of magnitude of each other ranging from 1x10^{-3} to 1x10^{-2} cm/s with the exception of RI-3 (1x10^{-4} cm/s).

10.4 K_{sbt} adjacent to Well-Screen Intervals

10.4.1 Prospect Island

The GM of K_{sbt} in five CPT soundings (PI-1, -3, -5, -6, and -10) with adjacent well screens that intersect the Upper Clay HU ranged from 3x10^{-7} cm/s to 5x10^{-5} cm/s with an overall GM of 2x10^{-6} cm/s (**Table 10-2**). The GM of K_{sbt} in nine CPT soundings with adjacent well screens that intersect the Main Sand HU range from 2x10^{-3} cm/s to 9x10^{-2} cm/s with an overall GM of 1x10^{-2} cm/s. There are four CPT soundings (PI-2, -7, -8, and -9) with adjacent well screens that intersect the Levee and Upper Clay HUs so their results are a composite. The GM of K_{sbt} in these four CPT soundings range from 3x10^{-7} cm/s to 2x10^{-6} cm/s with an overall GM of 7x10^{-7} cm/s. There are two soundings (PI-3 and PI-9) with adjacent well screens (PI-3C and -9C) that intersect a sand zone within the Lower Clay HU. The GM of K_{sbt} in these two soundings range from 1x10^{-5} cm/s to 9x10^{-5} cm/s with an overall GM of 3x10^{-5} cm/s.

10.4.2 Ryer Island

The GM of K_{sbt} in two CPT soundings (RI-4 and -5) adjacent to wells MW 99-4 and MW 99-8 that intersect the Upper Clay HU range from 3x10^{-6} cm/s to 3x10^{-5} cm/s with an overall GM of 9x10^{-6} cm/s (**Table 10-2**). The GM of K_{sbt} in four CPT soundings (RI-2, -3, -4, and -5) adjacent to wells MW 99-11, -5/6, -3/4, and -7/8, respectively that intersect the Main Sand HU range from 5x10^{-5} cm/s to 4x10^{-2} cm/s with an overall GM of 1x10^{-3} cm/s.

10.5 Summary of Prospect and Ryer Island K_{sbt} adjacent to Well-Screen Intervals

The overall K_{sbt} GMs adjacent to well screens that intersect the Upper Clay and Main Sand HUs are 3x10^{-6} cm/s and 5x10^{-3} cm/s, respectively. The overall K_{sbt} GMs adjacent to well screens that intersect the Levee/Upper Clay and sand within the Lower Clay HUs on Prospect Island are 7x10^{-7} cm/s and 3x10^{-5} cm/s, respectively (**Table 10-2**). **Figure**

10-3 suggests that the hydraulic conductivity in CPT soundings (K_{sbt}) adjacent to well screens in the Main Sand HU appears to be lowest on the west central portion of Ryer Island near sounding RI-3/well MW 99-5 at $5x10^{-5}$ cm/s and highest on the southern portion of Prospect Island near sounding PI-1/well PI-1B at $9x10^{-2}$ cm/s.

10.6 Pore Pressure Dissipation Testing (K_{ppdt})

Pore pressure dissipation testing (PPDT) was conducted at 38 depths in all 10 soundings on Prospect Island and at 26 depths in all eight soundings on Ryer Island. Hydraulic conductivity (K) was calculated for all tests using the processing tools in CPTu data presentation and interpretation software CPeT-IT v.1.7.6.42 (Geologismiki, 2007). The processed PPDT results are included in **Appendix E**. As part of this process, the pore pressures are plotted as a function of square root of time (t). The graphical technique suggested by Robertson and Campanella (1989), yields a value for t_{50}, which corresponds to the time for 50% consolidation. The value of the coefficient of consolidation in the radial or horizontal direction C_h was then calculated by Houlsby and Teh's (1988) theory using the following equation:

$C_h = T \times r^2 \times I_r^{0.5}/t_{50}$

where: T is the time factor given by Houlsby and Teh's (1988) theory corresponding to the pore pressure position
r: piezocone radius
I_r: stiffness index, equal to shear modulus G divided by the undrained strength of clay (S_u)
t_{50}: time corresponding to 50% consolidation

The dissipation of pore pressures during a CPTu dissipation test is controlled by the coefficient of consolidation in the horizontal direction (C_h) which is influenced by a combination of the hydraulic conductivity and compressibility (M), as defined by the following:

$K_h = C_h \times Y_w/M$

where: K_h is the hydraulic conductivity in the horizontal direction
C_h is the coefficient of consolidation in the horizontal direction
Y_w is the unit weight of water
M is the 1-D constrained modulus.

Following data processing, it was found that the majority of the tests, 50 out of 64 tests (78%), had very rapid t_{50} times (<60 seconds) which strongly suggests that the CPT penetration is partially drained and interpretation becomes more complex

(P. Robertson, personal communication, May 2, 2013) (**Table 10-3**). As a result, the theory tends to breakdown since the initial pore pressure distribution around the cone and dissipations are not fully understood. Since the CPT is likely partially drained, the theory is not valid and the calculated K values for these 50 samples are too low, due to the high cone resistance (q_c) values. The only finding that can be made regarding these 50 samples is that they represent essentially silty sand to sand with K>10^{-5} cm/s.

The remaining 14 out of 64 tests (22%) had t_{50} times >60 seconds suggesting undrained conditions which could be further analyzed (**Table 10-3**). The calculated K values for these 14 tests ranged from approximately $4x10^{-8}$ cm/s to $4x10^{-7}$ cm/s which appeared to be anomalously low in most cases. For comparison purposes, these test results were matched up to the collocated K_{sbt} data (**Figure 10-4**). In only 4 out of 14 comparisons (29%), the results matched up well to the collocated K_{sbt} data (meaning the data were within about one order of magnitude of each other). In the remaining 10 comparisons (71%), the results were well over one order of magnitude from the K_{sbt} data and not considered representative. Because the majority of the 14 K_{ppdt} results were not considered representative of the true K values of the HUs based on the K_{sbt} comparison, the K_{ppdt} results were not considered further in this study.

10.7 Slug Testing (K_{st})

Hydraulic conductivity (K_{st}) estimates for the aquifer materials adjacent to the screened intervals of 15 wells were obtained by performing pneumatic slug tests. This method involves pressurizing the air column in a sealed well by injecting air at the top of the well. This pressure lowers the water level in the well as water is pushed out of the well screen until the water level returns to equilibrium. When equilibrium is reached, the slug test is initiated by releasing the air pressure from the well and measuring the water level change. Water level changes were recorded at 0.5 second intervals using a data logger (In-Situ LevelTROLL 500). This slug testing was limited to wells where groundwater levels are above the top of the screen in the well. Pneumatic slug tests are not effective unless the well screen is completely submerged (below the water table) in the well. These tests are useful for determining aquifer properties around small-diameter wells that have short screened intervals. Unlike longer-term tests, the results are based on small changes in water level measured over short periods and, therefore, represent the hydraulic response from only a small volume of aquifer material next to the well screen (Butler, 1998).

The air pressure was applied to the well at the surface using a pneumatic slug test kit manufactured by Midwest Geosciences Group and a hand pump. A pressure gauge with units of inches equivalent head displacement was used to measure air pressure injected for each test. This amount should be very close to the initial head displacement observed in the corresponding test. Typically, six tests were performed in each well. The typical test sequence was as follows; Test 1 = 5 inches, test 2 = 10 inches, test 3 = 15 inches, test 4 = 15 inches, test 5 = 10 inches, test 6 = 5 inches. The initial head displacement observed for some tests differed from the equivalent head displacement. The cause of the difference is uncertain. The observed initial head displacement was used for processing the results.

The following assumptions were made for the interpretation of the slug testing data: the volume of water is displaced instantaneously at time (t = 0), and the well is of finite diameter and partially penetrates the aquifer. It is also assumed that the aquifer is confined, homogeneous, isotropic, and of uniform thickness; the flow within each aquifer is horizontal and radially symmetric; and that the response is influenced over the entire screened interval.

Slug testing data were analyzed using Aqtesolv software (Aqtesolv for Windows Version 4.50 – Professional, 1996-2007 HydroSOLVE, Inc). The most appropriate method for data analysis was selected based on a preliminary analysis of the slug test data and comparison with predicted responses from different methods. Slug tests from each well were analyzed and grouped on the basis of the shape of each type curve. Similarly shaped type curves were grouped together. For each approach, the individual tests were manually examined; tests that contained errors were removed from the batch. For each well, the results from all valid tests were averaged (using geometric mean) to estimate K for the given well. Wells PI-1B, PI-6B, MW 99-1, MW 99-7 and MW 99-11 were assumed confined and were analyzed with the McElwee-Zenner Nonlinear Model (McElwee and Zenner 1998). Wells PI-2B, PI-3B, -3C, PI-5B, PI-7B, PI-8B, PI-9B, -9C, PI-10B, and MW 99-5 were assumed confined and were analyzed with the KGS Model (Hyder et al. 1994). The results of the slug testing are shown in **Table 10-4**. The Aqtesolv analyses are presented in **Appendix F**.

10.8 K_{st} adjacent to Well-Screen Intervals

10.8.1 Prospect Island

The GM of K_{st} in nine wells (PI-1B, -2B, -3B, -5B, -6B, -7B, -8B, -9B, and -10B) with adjacent well screens that intersect the Main Sand HU ranged from $3x10^{-3}$ cm/s to $3x10^{-2}$ cm/s with an overall GM of $1x10^{-2}$ cm/s (**Table 10-4**). The GM of K_{st} in two wells with adjacent well screens that intersect the sand zone in the Lower Clay HU range from $8x10^{-4}$ cm/s to $2x10^{-2}$ cm/s with an overall GM of $5x10^{-3}$ cm/s.

10.8.2 Ryer Island

The GM of K_{st} in four wells (MW 99-1, -5, -7 and -11) with adjacent well screens that intersect the Main Sand HU ranged from 9x10^{-3} cm/s to 5x10^{-2} cm/s with an overall GM of 2x10^{-2} cm/s (**Table 10-4**).

10.9 Summary of Prospect and Ryer Island K_{st} adjacent to Well-Screen Intervals

The overall K_{st} GMs adjacent to well screens that intersect the Main Sand HU and Lower Clay (sand) HU are 1x10^{-2} cm/s and 5x10^{-3} cm/s, respectively. **Figure 10-5** suggests that the K_{st} adjacent to well screens in the Main Sand HU is lowest on the northern portion of Prospect Island near well PI-5B at 6x10^{-3} cm/s and highest on the west central portion of Ryer Island near well MW 99-1 at 4x10^{-2} cm/s.

10.10 Comparison of Slug Testing Results (K_{st}) to K_{sbt} Estimates

Overall, the estimated K_{st} GM for the Main Sand HU of 1x10^{-2} cm/s compares well to the CPT-derived K results including K_{sbt} GM of the Main Sand HU (3x10^{-3} cm/s) and K_{sbt} adjacent to Main Sand HU well-screen intervals (5x10^{-3} cm/s)(**Tables 10-1 and 10-2, Figure 10-6**). Furthermore, the various estimated K results for each CPT sounding also showed good comparability (**Appendix G**).

10.11 Hydraulic Conductivity Estimates from other recent Delta Projects

Kleinfelder (2007) Table K-1 reported the following K ranges:

- Low- to medium-plasticity clay: 10^{-5} to 10^{-6} cm/s
- Sand to clayey sand: 10^{-2} to 4x10^{-4} cm/s
- Gravel: 2.5x10^{-2} to 4x10^{-4} cm/s

URS (2009) Table 7-16 reported the following mean K ranges/values used for seepage model analyses:

- Sand (SM/SP): 10^{-3} cm/s
- Clay (CL): 10^{-6} cm/s

The K ranges and values reported in the above recent Delta studies compare favorably to the K_{sbt} GM estimates from this study as summarized below:

- Prospect-Ryer Island Levee HU: 2x10^{-5} cm/s
- Prospect-Ryer Island Upper Clay HU: 2x10^{-6} cm/s
- Prospect-Ryer Island Main Sand HU: 3x10^{-3} cm/s

10.12 Hydraulic Conductivity Estimated from Bed Sediment Samples

On February 14, 2013, 32 samples were collected from Miner Slough and the DWSC in order to characterize the bed sediments (**Figure 8-8**; DWR, 2013). The primary sampling locations were adjacent select Prospect Island groundwater monitoring well sites. Near each well site, three transect bed sediment samples were collected from the left bank (LB), centerline (CL), and right bank (RB) of Miner Slough (17 samples) and the DWSC (nine samples); these are identified as the MS-PI and DWS-PI series samples. It should be noted that sampling at proposed location MS-PI-10LB was attempted but was unsuccessful due to an interpreted hard channel bottom. Therefore, no results are reported for MS-PI-10LB. Additionally, bed sediment samples were also collected from the deepest portions of Miner Slough based on the results of the bathymetry survey (six samples); these are identified as the MS-DS series samples. The samples were submitted to DWR's Bryte Laboratory for grain size and hydrometer analysis and these results were first reported in DWR (2013).

Field textural descriptions were made on all 32 samples collected (**Table 8-2**). Of the 32 samples collected, 25 had sufficient volume to perform grain size and hydrometer analysis and seven samples had insufficient volume for testing (DWR, 2013). For the samples that were not laboratory tested, the field textural descriptions were used to make a qualitative analysis of K as either coarse grained (high K) or fine grained (low K).

Hydraulic conductivity (K) values were calculated from grain-size distribution data using SizePerm analysis software (EasySolve, 1998). The SizePerm software includes multiple methods for estimating K values from grain-size data, all of which were empirically developed through experimentation. Methods used to calculate K in SizePerm include Hazen, Slichter, Terzaghi, Beyer, Sauerbrei, Kruger, Kozeny, Zunker, Uma, and USBR. Certain coefficients and variables for different methods have been given fixed values in order to keep the program simple and easy to use. SizePerm calculates individual K values for each of the methods based on inputted sieve and hydrometer analysis data and documents the individual formulas as well as the values used for each variable and coefficient in the output report. The software also includes the range of applicability for each method which is based on effective grain diameter (de) and uniformity (n). When used appropriately, SizePerm provides an economic estimate of hydraulic conductivity for various applications including water resource evaluations. Additionally, the methods used in SizePerm are accepted by regulatory authorities (EasySolve, 1998).

Grain-size data, specifically grain size (mm) and percent finer than (%), from sieve analysis and hydrometer testing results for the 25 samples laboratory tested were entered into SizePerm. Hydraulic conductivity values were then calculated by SizePerm using the empirical equations listed above (**Table 10-5**). Individual K results for each method were then reviewed for applicability based on effective grain diameter (mm), uniformity, and the grain size distribution results (e.g. percent gravel, sand, silt, and clay).

Applicable K values calculated by SizePerm were summarized as a geometric mean for each grain-size analysis sample (**Table 10-5**). Prudic (1991) and other investigations have found that K is generally distributed log-normally for a variety of aquifer materials making the geometric mean more meaningful for determining effective hydraulic conductivity than the arithmetic mean.

Of the 25 samples that were laboratory tested, 22 samples (88%) had estimated K values that were consistent with the field textural descriptions (**Table 8-2**). Three of 25 samples (12%) had estimated K values that were not consistent with the field textural descriptions; all of these samples were described in the field as silty sand.

Of the 17 Miner Slough transect samples (MS-PI series) collected, 13 samples consisted of coarse-grained materials (silty sand, sand, and sand/gravel)(~76%) and four samples were composed of fine-grained materials (clay, sandy clay, and sandy clay with organics)(~24%) (**Figure 8-9**). Of the six MS-PI samples collected along the center line of Miner Slough (~83%) had coarse-grained textures; the one exception was sample MS-PI-10CL. Three of the four MS-PI samples with fine-grained textures were collected along the banks of Miner Slough.

Of the six Miner Slough deep spot samples (MS-DS series) collected, three samples were coarse grained and three samples were fine grained (**Figure 8-9**).

Of the nine DWSC transect samples (DWS-PI series) collected, five samples were coarse grained and four were fine grained (**Figure 8-9**). All three center channel samples from the DWSC had coarse-grained textures. The four DWS-PI samples with fine-grained textures were collected along the banks of the DWSC.

Of the 11 samples collected from the center line and deep spots along Miner Slough, eight had coarse-grained textures (~73%). Of the three samples collected from the center line of the DWSC, three had coarse-grained textures (100%). Overall, 21 out of 32 bed sediment samples (~66%) had coarse-grained textures which suggests that the majority of the bed sediments in the study area are sandy in nature and have high K values.

11.0 SURFACE WATER AND GROUNDWATER DATA ANALYSIS

Surface water and groundwater level monitoring from the existing network of 29 wells, three surface water stations (Miner Slough, Prospect Island, and DWSC), and three Ryer Island drainage ditch monitoring stations (**Figure 8-2**) is ongoing. Data from this network helps to characterize the subsurface hydrogeologic conditions in the Prospect and Ryer Island study area and further evaluate the potential for seepage to occur on Ryer Island as a result of the Project. Water level data is presented and analyzed in the form of hydrographs. The period of record for hydrographs included in this report is from December 21, 2011 to October 1, 2013. December 21, 2011 was the date that all 29 wells and three surface water stations began collecting concurrent data. During the summer of 2013, DWR staff added three surface water stations to drainage ditches on Ryer Island (**Figure 8-2**). Daily precipitation data from the Georgiana Slough Station (identified as GGS on CDEC) was used as a proxy for local precipitation in the study area.

11.1 Surface Water and Groundwater Interactions

The following analyses describe groundwater and surface water level changes during this study in order to gain an understanding of the mechanisms that cause the changes. Analyses were performed by reviewing water level data at all monitoring sites to determine how surface water and groundwater interact. This can also be done by looking at data corresponding to a HU across the study area.

11.1.1 Prospect Island Site Hydrographs

11.1.1.1 Sites PI-2 and PI-3

Sites PI-2 and PI-3 are located on the west side of Prospect Island, along the eastern levee of the DWSC (**Figure 8-2**). Groundwater levels in wells PI-2 and PI-3 correspond with DWSC stage and precipitation events (**Figures 11-1 and 11-2**). These hydrographs present daily mean water levels and show seasonal patterns. From about May through November, daily mean groundwater levels in wells PI-2B and -3B (Main Sand HU) and the DWSC are above the levels in wells PI-2A and -3A (Upper Clay HU). This indicates that there is an upward vertical hydraulic gradient from the Main Sand HU to the Upper Clay HU and that the DWSC is a losing stream. There is a downward vertical hydraulic gradient from well PI-3B (Main Sand HU) to PI-3C (sand within the Lower Clay HU) during the period of record.

The lowest daily mean water levels on Prospect Island and in the Upper Clay HU generally occur during August 2012. When the data are observed at two hour intervals during August 2012 (**Figures 11-3 and 11-4**), it can be seen that the groundwater levels in the Main Sand HU correlate well to the stage in the DWSC which indicates a significant hydraulic connection. Groundwater levels in the Upper Clay HU correlate weakly to the stage in the DWSC which indicates a limited hydraulic connection. The stage on Prospect Island has an even weaker correlation to stage in the DWSC which indicates a limited hydraulic connection. The data indicate that the DWSC is a losing stream and there is an upward vertical hydraulic gradient from the Main Sand HU to the Upper Clay HU during summer and fall.

From about December through April, groundwater levels in the Upper Clay HU are above the Main Sand HU and the DWSC. The highest daily mean water levels generally occur during December 2012. During this time, the DWSC appears to be a gaining stream and there is a downward vertical hydraulic gradient from the Upper Clay HU to the Main Sand HU. When the data are observed at two hour intervals during December 2012 (**Figures 11-5 and 11-6**), it can be seen that the groundwater levels in the Upper Clay HU and Prospect Island stage respond to precipitation events and do not respond significantly to stage changes in the DWSC.

11.1.1.2 Site PI-5

Site PI-5 is located on the northeast corner of Prospect Island, along the western levee of Miner Slough (**Figure 8-2**). Groundwater levels in wells at PI-5 correspond with Miner Slough stage and precipitation events (**Figure 11-7**). This hydrograph presents daily mean water levels and shows seasonal patterns. During the entire period of record, daily mean groundwater levels in wells PI-5A (Upper Clay HU) and -5B (Main Sand HU) correlate closely to each other and are consistently at least two feet below Prospect Island and Miner Slough stage. For most of the period of record, Prospect Island stage is below Miner Slough stage which indicates that Miner Slough is a losing stream at this location. Precipitation events in the winter and spring of each year appear to match up well to stage increases in Miner Slough and Prospect Island and to corresponding groundwater level increases.

The lowest daily mean water levels generally occur during the months of July and August. When the data are observed at two hour intervals during August 2012 (**Figure 11-8**), it can be seen that the groundwater levels in both wells correlate closely to each other which indicates a significant hydraulic connection. Approximately 0.5 foot groundwater level changes correspond with two to three feet of stage change in Miner Slough which suggests a significant hydraulic connection. Small Prospect Island stage changes of about 0.1 foot correspond with two to three feet stage changes in Miner Slough which suggests a limited hydraulic connection. On **Figure 11-7**, there are times during winter and spring when Prospect Island stage is above Miner Slough stage. During these times, there appears to be a hydraulic gradient from Prospect Island to

Miner Slough. However, when the data are observed at two hour intervals during December 2012 and January 2013 (**Figures 11-9 and 11-10**), it can be seen that the stage in Miner Slough rises above the stage on Prospect Island each day. This further indicates that the overall hydraulic gradient is from Miner Slough to Prospect Island and Miner Slough is predominantly a losing stream at this location.

11.1.1.3 Sites PI-6 through PI-10, and PI-1

Sites PI-6, PI-7, PI-8, PI-9, PI-10, and PI-1 are located along the western levee of Miner Slough (**Figure 8-2**). Groundwater levels in these wells respond similarly, so they were analyzed together. Groundwater levels in these wells correspond with Miner Slough stage and precipitation events (**Figures 11-11 through 11-16**). These hydrographs present daily mean water levels and show seasonal patterns. The groundwater levels in the Upper Clay HU are above groundwater levels in the Main Sand HU at all locations. This indicates a downward vertical hydraulic gradient from the Upper Clay HU to the Main Sand HU. Precipitation events in the winter and spring of each year appear to match up well to stage increases in Miner Slough and Prospect Island and to corresponding groundwater level increases.

The lowest daily mean water levels generally occur during August 2012. When the data are observed at two hour intervals during August 2012 (**Figures 11-17 through 11-22**), it can be seen that the groundwater levels in the Main Sand HU correlate well to Miner Slough stage which indicates a significant hydraulic connection. Groundwater level changes in wells in the Main Sand HU range from about 0.5 to two feet and correspond with two to three feet of stage change in Miner Slough. The most significant hydraulic connection of the Main Sand HU to Miner slough occurs at PI-10 and PI-1 (**Figures 11-21 and 11-22**). A possible explanation for this significant hydraulic connection may be that these two wells are located next to the two deepest scours in Miner Slough and a significant physical connection exists between the Miner Slough channel bottom and the Main Sand HU (**Appendix B and Figure 8-9**). **Figures 11-17 through 11-22** also show that groundwater levels in the Upper Clay HU correlate to Miner Slough stage, but to a lesser degree than the Main Sand HU which suggests a limited hydraulic connection. An exception to the above observation occurs at PI-10 (**Figure 11-21**), where groundwater levels in PI-10A are nearly identical to Miner Slough stage. A possible explanation for this observation is that well PI-10A is screened across a sand lens within the Prospect Island levee (**Figures 8-8 and 8-10**) that has a significant hydraulic connection to Miner Slough.

The highest daily mean water levels generally occur during December 2012. When the data are observed at two hour intervals (**Figures 11-23 through 11-28**), it can be seen that the groundwater levels in the Main Sand HU correlate to Miner Slough stage similar to observations in August 2012 which further supports a significant hydraulic connection. Prospect Island stage appears to be significantly influenced by local precipitation and minimally influenced by stage changes in Miner Slough and groundwater level changes.

11.1.1.4 Summary of Prospect Island Site Hydrographs

Overall, the data indicate that there is a significant hydraulic connection between the DWSC, Miner Slough, and the Main Sand HU due to the physical connection between the channel bottoms of DWSC and Miner Slough and the Main Sand HU (**Figure 8-9**). Prospect Island site hydrographs (**Figures 11-1 through 11-28**) indicate that stage on Prospect Island is influenced by local precipitation and stage in Miner Slough and the DWSC. Hydrographs show a generally downward vertical hydraulic gradient from the DWSC and Miner Slough to Prospect Island, which indicates that the DWSC and Miner Slough are predominantly losing streams in the study area. There is an upward vertical hydraulic gradient from the Main Sand HU to the Upper Clay HU along the western edge of Prospect Island due to the physical connection of the DWSC to the Main Sand HU (**Figure 8-9**). There is a downward vertical hydraulic gradient from the Upper Clay HU to the Main Sand HU along the eastern edge of Prospect Island.

11.1.2 Ryer Island Site Hydrographs

11.1.2.1 Sites MW 99-1 and -2

Wells MW 99-1 and -2 are located on the west side of Ryer Island, approximately 0.25 miles south of Elevator Road (**Figure 8-2**). Groundwater levels in these wells correspond with Miner Slough stage and precipitation (**Figure 11-29**). These hydrographs present daily mean water levels and show seasonal patterns. During the entire period of record, groundwater levels in wells MW 99-1 (Main Sand HU) and MW 99-2 (Upper Clay HU) are at least four feet below Prospect Island and Miner Slough stage, which indicates that Miner Slough is a losing stream at this location. During the entire period of record, groundwater levels in the Main Sand HU are above groundwater levels in the Upper Clay HU which indicates that there is an upward vertical hydraulic gradient from the Main Sand HU to the Upper Clay HU. Precipitation events in the winter and spring of each year appear to match up well to stage increases in Miner Slough and Prospect Island and to corresponding groundwater level increases. In the spring and summer, the groundwater level in well MW 99-2 (Upper Clay HU) begins to decrease more rapidly than the groundwater level in well MW 99-1 (Main Sand HU) and this is likely due to the operation of the Ryer Island drainage system which lowers shallow groundwater levels in order to create a seasonal unsaturated zone for crop growth.

The lowest daily mean water levels generally occur during the months of July and August. When the data are observed at two hour intervals during August 2012 (**Figure 11-30**), it can be seen that the groundwater level in well MW 99-1(Main Sand HU) correlates to stage in Miner Slough. Approximately 0.5 foot groundwater level change corresponds with two to three feet of water level change in Miner Slough, which indicates that a significant hydraulic connection exists between Miner Slough and the Main Sand HU at this location. **Figure 11-30** also shows that the groundwater level in well MW 99-2 (Upper Clay HU) correlates to Miner Slough stage, but to a lesser extent than in the Main Sand HU. Approximately 0.1 foot of groundwater level change corresponds with two to three feet of stage change in Miner Slough which indicates a limited hydraulic connection. Data indicate that Miner Slough is a losing stream at wells MW 99-1 and -2 during the summer and fall. When the data are observed at two hour intervals during December 2012 (**Figure 11-31**), it can be seen that the groundwater level in the Upper Clay HU and stage on Prospect Island correlate more with precipitation than with Miner Slough stage. Additionally, the groundwater level in well MW 99-2 (Upper Clay HU) shows small increases during the spring and summer which are likely caused by irrigation activities.

11.1.2.2 Sites MW 99-3 and -4 and MW 99-11

Wells MW 99-3 and -4 are located on the west side of Ryer Island, approximately 0.5 miles north of Elevator Road and well MW 99-11 is located on the west side of Ryer Island, on top of the levee, about 0.25 miles north of Elevator Road (**Figure 8-2**). The groundwater levels in these wells (MW 99-3, -4, and -11) respond similarly so they were analyzed together. Groundwater levels in these wells correspond with Miner Slough Stage and precipitation (**Figures 11-32 and 11-33**). These hydrographs present daily mean water levels and show seasonal patterns. During the entire period of record, daily mean groundwater levels in wells MW 99-3 and MW 99-11 (Main Sand HU) and MW 99-4 (Upper Clay HU) are below Miner Slough and Prospect Island stage. This indicates that Miner Slough is a losing stream at this location. During the entire period of record, daily mean groundwater levels in the Main Sand HU are above those in the Upper Clay HU which indicates that there is an upward vertical hydraulic gradient from the Main Sand HU to the Upper Clay HU at this location. Precipitation events in the winter and spring of each year appear to match up well to stage increases in Miner Slough and Prospect Island and to corresponding groundwater level increases.

During the spring of 2012 and winter of 2013, data indicates that groundwater levels in well MW 99-4 (Upper Clay HU) rose to one foot or less below the ground surface. These occurrences appear to coincide with precipitation events, stage increases in Miner Slough, and potentially the seasonal change in drainage system operation, which needs to be further evaluated. If groundwater levels in the shallow aquifer system rise to within one foot or less below the ground surface, agricultural activities may be affected due to the saturation of shallow-depth, clay-rich soils. Furthermore, if shallow aquifer groundwater levels are close to the ground surface and a precipitation event occurs, there is little to no unsaturated zone available for precipitation to infiltrate into and ponding may result. Data analysis indicates that this phenomenon occurs on Ryer Island.

In the spring and summer, the groundwater level in well MW 99-4 (Upper Clay HU) begins to decrease more rapidly than the groundwater level in well MW 99-3 (Main Sand HU) and this is likely due to the operation of the Ryer Island drainage system which lowers shallow groundwater levels in order to create a seasonal unsaturated zone for crop growth. Additionally, the groundwater level in well MW 99-4 (Upper Clay HU) shows small increases during the spring and summer which are likely caused by irrigation activities.

The lowest daily mean water levels generally occur during the months of July and August. When the data are observed at two hour intervals during August 2012 (**Figures 11-34 and 11-35**), it can be seen that the groundwater levels in the Main Sand HU at wells MW 99-3 and -11 correlate to stage in Miner Slough. Approximately 0.5 foot change in well MW 99-3 and 0.75 foot change in well MW 99-11 correspond with two to three feet of stage change in Miner Slough which indicates a significant hydraulic connection between Miner Slough and the Main Sand HU at these locations. **Figure 11-34** also shows that the groundwater level in well MW 99-4 (Upper Clay HU) correlates to Miner Slough stage, though not as significantly as in the Main Sand HU. A sharp one foot increase in the groundwater level of well MW 99-4 occurred on August 18, 2012. Based on the timing, the increase is likely due to irrigation activities on Ryer Island. The groundwater level in the Upper Clay HU is about 3 feet lower than the groundwater level in the Main Sand HU and about 0.2 foot of change corresponds with two to three feet of stage change in Miner Slough.

When the water levels are observed at two hour intervals during December 2012 (**Figure 11-36 and 11-37**), it can be seen that the groundwater level in the Upper Clay HU and Prospect Island stage correlate more with precipitation than with stage changes in Miner Slough.

11.1.2.3 Sites MW 99-5 and -6 and MW 99-7 and -8

Wells MW 99-5 and -6 are located on the west side of Ryer Island, approximately 0.5 miles north of Elevator Road and 0.75 miles east of Miner Slough and wells MW 99-7 and -8 are located on the west side of Ryer Island, approximately one mile north of Elevator Road and 0.5 miles east of Miner Slough (**Figure 8-2**). The groundwater levels in these wells (MW 99-5, -6, -7, and -8) respond similarly so they were analyzed together. Because the Upper Clay HU is relatively thin at these locations (**Figure 8-14**), all of the wells are monitoring the Main Sand HU except for well MW 99-8 which monitors the Upper Clay HU. Wells MW 99-5 and 99-7 are the deep wells and MW 99-6 and 99-8 are the shallow wells. Groundwater levels in these wells correspond with Miner Slough stage and local precipitation (**Figures 11-38 and 11-39**). These hydrographs present daily mean water levels and show seasonal patterns. During the entire period of record, daily mean groundwater levels in wells MW 99-5, -6, -7, and -8 are below Prospect Island and Miner Slough stage. This indicates that Miner Slough is a losing stream at these locations. During most of the period of record, daily mean groundwater levels in the deep wells (MW 99-5 and 99-7) are above the groundwater levels in the shallow wells (MW 99-6 and 99-8) which indicates that there is an upward vertical hydraulic gradient at these locations.

During the winter and spring periods, data indicates that groundwater levels rise to within one foot of the ground surface, and in some cases, above the ground surface. These occurrences appear to coincide with precipitation events, stage increases in Miner Slough, and potentially the seasonal change in drainage system operation, which needs to be further evaluated. If groundwater levels in the shallow aquifer system rise to within one foot or less below the ground surface, agricultural activities may be affected due to the saturation of shallow-depth, clay-rich soils. If groundwater levels in the shallow aquifer system rise above the ground surface, groundwater seepage occurs. Furthermore, if the shallow groundwater levels are close to or above the ground surface and a precipitation event occurs, there is little to no unsaturated zone available for precipitation to infiltrate into and ponding may result. Data analysis indicates that this phenomenon occurs on Ryer Island at these locations.

During the spring and summer periods, the groundwater levels in all wells decrease up to several feet and this is likely the result of the operation of the drainage system which lowers the shallow groundwater levels in order to create a seasonal unsaturated zone for crop growth.

The lowest daily mean water levels generally occur during the months of July and August. When the data are observed at two hour intervals during August 2012 (**Figures 11-40 and 11-41**), it appears that water levels in the Main Sand HU correlate to stage in Miner Slough. Approximately 0.2 foot groundwater level changes correspond with two to three feet of stage change in Miner Slough. This indicates that a significant hydraulic connection exists between Miner Slough and the Main Sand HU at these locations. A rapid increase of about 0.5 feet in the groundwater level in well MW 99-8 occurred on August 17, 2012. A similar increase is observed in wells MW 99-5 and -6. Based on the timing, these increases are likely related to irrigation activities on Ryer Island.

When the water levels are observed at two hour intervals during December 2012 (**Figure 11-42 and 11-43**), it can be seen that the groundwater level in the Upper Clay HU and Prospect Island stage correlate more with precipitation than with stage changes in Miner Slough. During the entire month of December, 2012, all groundwater levels are above the ground surface elevation at these locations (**Figures 11-42 and 11-43**). This is significant because when groundwater levels in the shallow aquifer system rise above the ground surface, groundwater seepage occurs. Furthermore, since the shallow groundwater levels are above the ground surface, any precipitation that occurs will result in ponding because there is no unsaturated zone available for the precipitation to infiltrate into.

11.1.2.4 Summary of Ryer Island Site Hydrographs

Overall, the data indicate that there is a significant hydraulic connection between Miner Slough and the Main Sand HU due to the physical connection between the channel bottom of Miner Slough and the Main Sand HU (**Figure 8-9**). Ryer Island site hydrographs (**Figures 11-29 through 11-43**) indicate that groundwater levels on Ryer Island are significantly influenced by local precipitation and stage in Miner Slough. Hydrographs show a significant vertical hydraulic gradient from Miner Slough to Ryer Island which indicates that Miner Slough is a losing stream in the study area. There is an upward vertical hydraulic gradient from the Main Sand HU to the Upper Clay HU at all monitoring well sites.

During the winter and early spring, groundwater levels are close to or above the ground surface elevation on Ryer Island. These conditions coincide with precipitation events, stage increases in Miner Slough, and potentially the seasonal change in drainage system operation, which needs to be further evaluated. This is significant because when groundwater levels in the shallow aquifer system rise to within a foot or less from the ground surface, agricultural activities may be affected due to the saturation of shallow-depth, clay-rich soils. Also, when groundwater levels in the shallow aquifer system rise above the ground surface, groundwater seepage occurs. Furthermore, when the shallow groundwater levels are close to or above the ground surface, any precipitation that occurs will result in ponding because there is little to no unsaturated zone available for the precipitation to infiltrate into.

During the spring and summer, the groundwater levels on Ryer Island decrease up to several feet and this is likely due to the operation of the Ryer Island drainage system which lowers shallow groundwater levels in order to create a seasonal unsaturated zone to grow crops. Additionally, groundwater levels in wells MW 99-2, -4, -5, -6, -7, and -8 show small increases during the spring and summer which are likely caused by irrigation activities.

11.1.3 Transect Hydrographs

Representative transect hydrographs (**Figures 11-44, 45, 46**) were analyzed to see how surface and groundwater interact along the seepage transects (**Figure 12.1**). For analysis, the nearest wells to the seepage transects were used to represent water levels along transects. These hydrographs present daily mean water levels and show seasonal patterns. Observations from the transect hydrographs support findings from the site hydrographs of Section 11.1. The following analyses describe findings unique to the transect hydrographs.

11.1.3.1 North Seepage Transect

For the north seepage transect hydrograph, surface water stage at Prospect Island and Miner Slough, groundwater level in PI-6A, PI-6B, MW 99-7, MW 99-8, MW 99-9 and MW 99-10, and local precipitation at Georgiana Slough were analyzed together (**Figure 11-44**). The data indicates that the groundwater level in the Main Sand HU (MW 99-9 and MW -99-7) near the north seepage transect responds to Miner Slough stage and attenuates to the east beneath Ryer Island. The groundwater levels in MW 99-9 are above groundwater levels in MW 99-7. Because MW 99-7 is farther from Miner Slough than MW 99-9, this indicates a hydraulic gradient in the Main Sand HU that slopes to the east beneath Ryer Island.

11.1.3.2 Middle Seepage Transect

For the middle seepage transect hydrograph, surface water stage at Prospect Island and Miner Slough, groundwater level in PI-8A, PI-8B, MW 99-3, MW 99-4, MW 99-5, MW 99-6 and MW 99-11, and local precipitation at Georgiana Slough were analyzed together (**Figure 11-45**). The groundwater levels in MW 99-11 (Main Sand HU) are above groundwater levels in MW 99-3 (Main Sand HU). Because MW 99-3 is farther from Miner Slough than MW 99-11, this indicates a hydraulic gradient in the Main Sand HU that slopes to the east beneath Ryer Island. The groundwater levels in MW 99-3 (Main Sand HU) are above groundwater levels in MW 99-5 (Main Sand HU). Because MW 99-5 is farther from Miner Slough than MW 99-3, this indicates a hydraulic gradient in the Main Sand HU that slopes to the east beneath Ryer Island. The data indicate that the groundwater levels in the Main Sand HU near the middle seepage transect respond to Miner Slough stage and attenuate to the east beneath Ryer Island.

11.1.3.3 South Seepage Transect

For the south seepage transect hydrograph, surface water stage at Prospect Island and Miner Slough, groundwater levels in PI-1A, PI-1B, PI-2A and PI-2B, and local precipitation at Georgiana Slough were analyzed together (**Figure 11-46**). The groundwater levels in PI-1B and PI-2B (Main Sand HU) both correlate well with Miner Slough stage and groundwater levels in PI-1B are generally two feet lower than in PI-2B. This indicates that groundwater flows from west to east in the Main Sand HU along the south seepage transect. The water levels in PI-1A and PI-2A (Upper Clay HU) correlate more with Prospect Island stage than with Miner Slough stage. From about May to December 2012, the PI-1A groundwater level is above the PI-2A groundwater level, indicating a decreasing horizontal hydraulic gradient from PI-1 to PI-2 in the Upper Clay HU. From about December 2012 to May 2013, PI-2A water level is above PI-1A water level, indicating a decreasing horizontal hydraulic gradient from PI-2 to PI-1 in the Upper Clay HU. This indicates that groundwater flow in the Upper Clay HU changes seasonally beneath the south seepage transect on Prospect Island.

11.2 Ryer Island Drainage Ditch Water Level Monitoring

On July 25, 2013, DWR staff installed three surface water monitoring stations in drainage ditches on Ryer Island (**Figure 8-2**). The monitoring stations are made of five foot long, two inch diameter acrylonitrile butadiene styrene (ABS) pipes attached to eight foot long fence posts. The fence posts were driven into the bottom of the ditch and fastened to the downstream side of the weir at each location.

Two stations were installed in Elkhorn Slough and one station was installed in West Canal (**Figure 8-2**). These stations were surveyed (**Table 11-1**) and are equipped with pressure transducers collecting water level data at 15-minute intervals.

A hydrograph showing the drainage ditch water levels, groundwater levels from wells MW 99-5, -6, -7, and -8, precipitation, and Miner Slough and Prospect Island stage was prepared and analyzed (**Figure 11-47**). Groundwater levels, and to a limited extent drainage ditch stage, appear to correspond to Miner Slough stage. There are also fluctuations in drainage ditch stage that do not correspond to groundwater level changes, and these are likely caused by irrigation activities on Ryer Island. Additionally, there was a precipitation event that occurred on September 21, 2013 and a small response was observed at the West Canal and Elkhorn Slough 1 stations. As additional data are collected at these locations, the interaction between drainage ditch stage and groundwater levels will be further evaluated.

11.3 Potentiometric Surface Mapping

Potentiometric surface contour maps were prepared for two time periods (summer and winter 2012) in order to show a range of hydrologic conditions that occur in the Shallow (Upper Clay HU) and Main Sand (Main Sand HU) Aquifers within the study area. Data analysis indicates that groundwater in the Shallow Aquifer is significantly connected to surface water in Miner Slough, DWSC, and Prospect Island. Data analysis also shows that groundwater in the Main Sand Aquifer is significantly connected to surface water in Miner Slough and DWSC and not significantly connected to surface water on Prospect Island.

11.3.1 Summer Period (August 9, 2012)

During the summer period, water surface elevations in the Shallow Aquifer and Main Sand Aquifers ranged from 3.38 feet (Miner Slough) to -6.65 feet on Ryer Island (ENGEO Well 1-P-06) (**Figures 11-48 and 11-49**). Since Miner Slough had the highest stage at 3.38 feet, it formed a water divide for both aquifers with groundwater flowing west onto and across Prospect Island and into the DWSC (which acted as a gaining stream) and eastward onto Ryer Island. These findings are also observed in the summer of 2011 and 2013 (**DWR, 2013, and Figures 11-1 and 11-7**).

11.3.2 Winter Period (December 26, 2012)

During the winter period, water surface elevations in the Shallow Aquifer and Main Sand Aquifer ranged from 9.59 feet (Miner Slough) to -3.75 feet on Ryer Island (ENGEO Well 1-P-06) (**Figures 11-50 and 11-51**). Similar to the summer period, Miner Slough stage was the highest at 9.59 feet and formed a water divide for both aquifers with groundwater flowing west onto Prospect Island and eastward onto Ryer Island. During this period, the stage in the DWSC was higher than the potentiometric surface in the Shallow and Main Sand Aquifers, so the DWSC acted as a losing stream and water flowed from the DWSC eastward onto Prospect Island.

11.3.3 Summary

The potentiometric surface contour maps during these two periods indicate that Miner Slough is the dominant hydrologic feature affecting groundwater flow within the study area.

12.0 SEEPAGE ANALYSES

To evaluate potential impacts from the Project, two-dimensional, finite element models were used to analyze seepage conditions. This modeling approach was chosen as it considers the major elements of the subsurface hydrogeology along each transect. The models were created to analyze seepage conditions along transects that cross the levees and sloughs (Miner Slough – North, Middle, South transects; DWSC – South transect) and were developed to model average and high Miner Slough stage, and subsurface conditions. Three seepage model scenarios were evaluated under two different stage conditions (**Figure 12-1; Table 12-1**) to determine if there may be any impacts to adjacent areas from the Project;

- Past Conditions (Dry Prospect Island)
    - Average stage (period of record) and high Miner Slough stage (12/26/2012)

- Existing Conditions (Flooded Prospect Island – No levee breach)
    - Average stage (period of record) and high Miner Slough stage (12/26/2012)

- Restored Conditions (Flooded Prospect Island – Levee breached and connected to Miner Slough)
    - Average stage (period of record) and Miner Slough high stage (12/26/2012)

The effects of seepage from Miner Slough, DWSC, and the Project can be modeled using this method. The surface water stage and groundwater levels vary significantly on a daily (tidal) and seasonal basis within the study area (**Figures 11-1 through 11-43**). In order to determine if there are any impacts caused by the Project, both average stage and high stage conditions (that would result in maximum head and flow) were used. The high stage conditions were determined based on the highest stage of Miner Slough during the period of record for this study (9.6 feet (NAVD88) 12/26/2012 15:30). The remaining model inputs were chosen at this same time interval or were approximated based on the best available data.

The cross sectional models developed for the seepage analysis were used to estimate parameters that were considered critical for the evaluation of Project. Specific parameters include:

- The total head (in feet) in the Main Sand HU underlying the Ryer Island levee
- The total groundwater flow through a vertical section, termed the seepage flux (in cubic feet per second [ft^3/s]) through the middle of the Ryer Island levee.

Total head and groundwater flow were considered to be an important indicator of impacts detrimental to adjacent islands, as a significant rise in total head and/or groundwater flow may impact agricultural operations.

The hydraulic conductivities used in each model transect across Prospect and Ryer Islands are presented in **Table 12-2**. The results of the 3D lithologic model and HU boundaries along each transect are presented in (**Figures 12-2 through 12-4**).

12.1 Computer Model

The computer software SEEP/W (Geo-Slope International Ltd., 2007-Version 7.17) was used to estimate seepage conditions through transects of Prospect and Ryer Islands. SEEP/W uses a two-dimensional finite element model to analyze seepage conditions and assumes that flow through both saturated and unsaturated media follows Darcy's Law. The seepage analyses were conducted considering steady-state conditions. Using the SEEP/W mesh generation capability, finite element meshes were generated to model the multiple seepage conditions considered for the three scenarios. Material regions were created based on the subsurface HUs, described in Section 8, and are represented in the models as different colors (**Figures 12-5 through 12-10**). Constant head boundary conditions were used to model Miner Slough, Prospect Island, DWSC, and groundwater levels. The remaining areas of levee and ground surfaces on the islands were modeled using an unrestricted, free-flowing boundary condition that is determined at each node by SEEP/W during the analysis procedure. The bottom of the north, middle, and south transect was modeled with no-flow boundary condition as well as the western boundary of the north and middle transect (**Figures 12-5 through 12-10; Table 12-1**).

The SEEP/W program was used to evaluate the steady-state phreatic surface, the head distribution throughout the model, and flow quantities at selected locations. The SEEP/W contouring option was used to generate head distribution diagrams. Phreatic surface, total head contours (in feet), and flux quantities (in ft^3/s per foot width of levee) are presented on each scenario summary figure (**Figures 12-5 through 12-10**). The flux quantities represent the flow quantity across the length of a particular flux section, which is symbolized as a blue arrow on the figures. The phreatic surface is represented by a dashed blue line.

12.2 Seepage Transect Locations

Three transects were considered for the seepage analysis (**Figure 12-1**). The transects were selected in the north, middle, and south portion of the study area adjacent to Miner Slough and the DWSC was included as the western extent of the south transect. These locations were chosen to model the more critical seepage conditions based on the RD 501 reported seepage areas, and physical and hydraulic connection of Miner Slough to the Main Sand HU. The more critical seepage conditions are expected to occur at locations where Miner Slough is connected to the Main Sand HU.

The subsurface conditions and the approximate thickness of each layer are shown in **Figures 12-2 through 12-4**. The sequence of layers included in each transect are; Levee adjacent to Miner Slough and DWSC underlain by the Upper Clay, Main Sand,

and Lower Clay. It should be noted, a seepage transect was not selected near the restored wetland on Ryer Island because of the possible influence of this feature on the surrounding land.

12.3 Seepage Transect Scenarios

Three scenarios were evaluated for each transect; 1) past conditions - dry Prospect Island, 2) existing conditions – flooded Prospect Island with no Miner Slough levee breach, and 3) restored conditions – flooded Prospect Island with Miner Slough levee breach and the same stage on Prospect Island and in Miner Slough. Each scenario was evaluated using two conditions; average stage and high stage.

12.4 Seepage Transect Boundary Conditions

The boundary conditions affecting the seepage models include the constant head boundaries of Miner Slough, Prospect Island, DWSC, and the groundwater conditions within the study area. Surface water stage and groundwater levels vary significantly on a daily (tidal) and seasonal basis within the study area (**Figures 11-1 through 11-43**). The average values were considered representative and used in the analyses. Miner Slough was evaluated at two different stages for each scenario; 1) Miner Slough at 5 feet (NAVD 88) which is the average stage during the period of record of this study and is considered the typical seepage flow that would occur, and 2) Miner Slough at 10 feet (NAVD 88) which is the highest stage of Miner Slough during the period of record of this study (9.6 feet (NAVD 88) 12/26/2013 15:30) and is considered a conservative estimate because high flows in Miner Slough are rare and last for short periods of time. The remaining boundary conditions were selected based on the best available data to match the average condition or the high stage condition. The groundwater constant head boundary conditions at the extents of each transect were modeled based on the average stage in the closest of three drainage ditch monitoring stations installed during this project (see Section 11, **Figure 8-2**).

12.5 Seepage Transect Hydraulic Conductivities

The hydraulic conductivity values used for each layer are documented in Section 10 and summarized in **Table 12-2.**

12.6 Seepage Transect Analysis Results

The seepage results for each transect are presented in **Figures 12-5 through 12-10** and summarized in **Table 12-3.** Each seepage transect location is summarized by two figures, one displaying the average conditions and another displaying the high stage conditions. Each summary figure includes; 1) the transect geometry and hydraulic conductivity data, 2) the past conditions - dry Prospect Island, 3) existing conditions – flooded Prospect Island with no Miner Slough levee breach, and 4) restored conditions – flooded Prospect Island with Miner Slough levee breach and the same stage on Prospect Island and in Miner Slough. All of the seepage results include total head contours (in feet), phreatic surface, and flux section (flow quantity) across a vertical line through the middle of the Ryer Island levee.

12.6.1 North Seepage Transect

Along the north transect the surface water and groundwater system are physically and hydraulically connected (**Figure 12-2,** see Section 11). Bed sediment samples in Miner Slough collected near this transect (MS-PI-6-LB,CL,RB and MS-DS-1) are sand on the left bank, center line, and right bank, and clay in sample MS-DS-1 (**Table 8-8**)**,** which supports the 3D lithologic model results of a physical connection between the Main Sand HU and the Miner Slough channel bottom (**Figure 8-9 and Table 10-5**).

The total head within the Main Sand HU at the Ryer Island levee is about 4 feet (average stage) and 8 feet (high stage) and gradually decreases to -3 feet (boundary condition stage) at the eastern model boundary, which is the average stage of the closest drainage ditch monitoring station (Elkhorn Slough 2, **Figure 8-2; Figure 12-5 and 12-6; Table 12-3**). This indicates that surface water from Miner Slough enters the Main Sand HU and flows east beneath and to the surface of Ryer Island.

The change in total head in the Main Sand HU under the Ryer Island levee from the past scenario to the existing scenario for both average and high stage conditions is 0.01 feet or less and 0.02 feet or less from the existing scenario to the restored scenario (**Table 12-3; Figures 12-5 and 12-6**). This indicates that there is little to no change in total head (groundwater levels) under Ryer Island as a result of Prospect Island flooding.

The change in groundwater flow through the vertical flux section located in the middle of the Ryer Island levee from the past scenario to the existing scenario for both average and high stage conditions is 0.08% or less and 0.20% or less from the existing scenario to the restored scenario (**Table 12-4; Figures 12-5 and 12-6**)**.** This indicates that there is little to no effect on groundwater flow toward Ryer Island as a result of Prospect Island flooding.

12.6.2 Middle Seepage Transect

Along the Middle transect the surface water and groundwater system are physically and hydraulically connected (**Figure 12-3,** see Section 11). Bed sediment samples in Miner Slough collected near this transect (MS-PI-8-LB,CL,RB) in Miner Slough are silty sand –

right bank, sand – center line, and clay – left bank (**Table 8-8**), which supports the 3D lithology modeling results of a physical connection between the Main Sand HU and the Miner Slough channel bottom (**Figure 8-9 and Table 10-5**).

The total head within the Main Sand HU at the Ryer Island levee is about 4 feet (average stage) and between 8 and 9 feet (high stage) and gradually decreases to -5 feet (boundary condition stage) at the eastern model boundary, which is the average stage of the closest drainage ditch monitoring station (West Canal, **Figure 8-2; Figure 12-7 and 12-8; Table 12-3**). This indicates that surface water from Miner Slough enters the Main Sand HU and flows east beneath and to the surface of Ryer Island.

The change in total head in the Main Sand HU under the Ryer Island levee from the past scenario to the existing scenario for both average and high stage conditions is 0.14 feet or less and 0.04 feet or less from the existing scenario to the restored scenario (**Table 12-3; Figures 12-5 and 12-6**). This indicates that there is little to no change in total head (groundwater levels) under Ryer Island as a result of Prospect Island flooding.

The change in groundwater flow through the vertical flux section located in the middle of the Ryer Island levee from the past scenario to the existing scenario for both average and high stage conditions is 1.1% or less and 0.30% or less from the existing scenario to the restored scenario (**Table 12-4; Figures 12-7 and 12-8).** This indicates that there is a slight increase, less than 1.1%, in groundwater flow beneath and to the surface of Ryer Island when comparing the past scenario to the existing scenario. This increase in groundwater flow is absent (less than 0.30% change) when the existing and restored scenarios are compared, which is more applicable to the Project because it will be started from the existing conditions and not a dry Prospect Island. The change in Prospect Island stage from the existing to the restored scenario has little to no effect on total head and groundwater flow toward Ryer Island.

12.6.3 South Seepage Transect

Along the south transect the surface water and groundwater system are physically and hydraulically connected (**Figure 12-4,** see Section 11). Bed sediment samples in Miner Slough collected near this transect (MS-PI-1-LB, CL, RB and MS-DS-6) are sand in the left bank and center line and clay on the right bank, and sand in sample MS-DS-6, which supports the 3D lithology modeling results of a physical connection between the Main Sand HU and the Miner Slough channel bottom (**Figure 8-9 and Table 10-5**).

The total head within the Main Sand HU at the Ryer Island levee is about 4 feet (average stage) and between 9 feet (high stage) and gradually decreases to -7 feet (boundary condition stage) at the eastern model boundary, which was estimated based on the land surface elevation and the closest drainage ditch monitoring station (Elkhorn Slough 1, (**Figure 8-2; Figure 12-9 and 12-10; Table 12-3**)**.** This indicates that surface water from Miner Slough enters the Main Sand HU and flows east beneath and to the surface of Ryer Island.

The change in total head in the Main Sand HU under the Ryer Island levee from the past scenario to the existing scenario for both average and high stage conditions is 0.0014 feet or less and 0.0015 feet or less from the existing scenario to the restored scenario (**Table 12-3; Figures 12-9 and 12-10**). This indicates that there is little to no change in total head (groundwater levels) under Ryer Island as a result of Prospect Island flooding.

The change in groundwater flow through the vertical flux section located in the middle of the Ryer Island levee from the past scenario to the existing scenario for both average and high stage conditions is 0.01% or less and 0.01% or less from the existing scenario to the restored scenario (**Table 12-4; Figures 12-9 and 12-10**)**.** This indicates that there is little to no effect on groundwater flow toward Ryer Island as a result of Prospect Island flooding.

13.0 FINDINGS

13.1 Overview of Prospect Island Flooding, Ownership, and Legal Information, and Ryer Island Seepage History

- Prospect Island is part of the Yolo Bypass and has restricted height levees. It serves as an overflow basin for this portion of the Yolo Bypass, and as a result, during high-flow events, Prospect Island typically floods first and more frequently than surrounding islands.

- Prospect Island has a significant history of flooding dating back to the early 1900s (Hopf, 2011 and URS, 2009). It is reported that Prospect Island has flooded 13 times since 1919 (Hopf, 2011). Since 1962, Prospect Island has flooded at least seven times in the following years: 1963, 1980, 1981, 1983, 1986, 1995, and 1997 (**Table 5-1**).

- From May 1963 through January 1995, Prospect Island was owned by Sakata Brothers Inc. and during that time period, Prospect Island flooded four times (**Table 5-1**). In that 32 year time period, it is unknown if any complaints were filed by Ryer Island entities against Sakata Brothers Inc. alleging that flooding of Prospect Island was causing seepage impacts on Ryer Island. Prospect Island was transferred from Sakata Brothers Inc. to the Trust for Public Land and then to the USBR on January 3, 1995. DWR acquired the northern 1,300 acre portion of Prospect Island from the federal government through the Public Benefit Conveyance process in January 2010.

- In 1996, Islands, Inc. filed a complaint against USBR for crop damage allegedly caused by subsurface movement of groundwater from Prospect Island to Ryer Island (Leagle.com, 2012) (**Table 5-1**). On August 26, 1996, Sam Sakata Farms filed a complaint for damages alleging that hydrologic pressure from flooded conditions on Prospect Island had resulted in flooding on Ryer Island (Todd, 1998).

- In 1999, the Islands, Inc. complaint was dismissed due to federal government immunity from suit under the Flood Control Act (Leagle.com, 2012). It is unknown what the end result was of the Sam Sakata Farms complaint.

- On September 3, 1999, RD 501 and Islands, Inc. filed a complaint against USACE and DWR claiming that the Prospect Island Ecosystem Restoration Project environmental document was inadequate and the decision to leave Prospect Island in a submerged state caused and continues to cause seepage under land owned by Islands, Inc. and for which RD 501 has reclamation responsibility (RD 501 and Islands, Inc., 1999) (**Table 5-1**). Furthermore, they claimed that the seepage prevented the overlying farmland from growing crops which have historically been grown and caused farm equipment to become mired in the saturated soil. It is unknown what the end result was of this complaint. Also, it is unknown if any additional complaints were filed by Ryer Island entities since 1999.

- In the Delta, seepage is a regional problem because much of the land surface is below sea level (Priestaf, 1983. URS, 2009). The Ryer Island portion of the study area has land surface elevations that range from slightly above sea level to more than 5 feet below sea level, excluding the levees.

- Bulletin 125 (DWR, 1967) documented that extensive seepage extended 1,000 feet or more into the interior of Ryer Island from Miner Slough following two high-flow events in 1963 and 1964-65 (**Figure 5-1**). It was reported that Prospect Island flooded during the 1963 event, but not during the 1964-65 event. However, both high-flow events resulted in significant and similar areas of mapped seepage on Ryer Island that extended beyond the Miner Slough levee and well into the island's interior (with and without the flooding of Prospect Island).

- Considering the significant seepage reported on Ryer Island in Bulletin 125 with flooding (1963) and without flooding (1964-65) on Prospect Island, it seems likely that extensive seepage occurred on Ryer Island during the four high-flow events that caused Prospect Island to flood between May 1963 and January 1995; a time period in which Prospect Island was owned, operated, and maintained by a private party, Sakata Brothers, Inc. It is unknown if any reports of increased seepage problems on Ryer Island were made by landowners following the four preceding high-flow events between 1963 and 1995 when Prospect Island flooded.

- On January 5, 2010, DWR-NCRO staff made their first visit to Ryer Island with DWR-Division of Environmental Services staff and Ryer Island stakeholders. During this visit, DWR obtained valuable information from the stakeholders about past and present Ryer Island conditions. The most significant information reported was that seepage conditions in some areas of Ryer Island adjacent to Miner Slough and Prospect Island have significantly impacted agricultural operations. The stakeholders are concerned that DWR's plan to restore Prospect Island to a tidal habitat will exacerbate the seepage problem. NCRO staff obtained a map from Mr. Tom Hester (RD 501) that identified areas where the seepage problems occur and those areas are superimposed on **Figure 5-1** for reference.

- In general, the reported seepage areas from RD 501 in 2010 are coincident with the mapped areas of seepage from Bulletin 125 (1967).

- The spatial and temporal extents of the RD 501 reported seepage areas are not well defined.

13.2 Geologic and Geomorphic Setting

- The majority of the Ryer Island land surface is well below (approximately 5 feet) the average water surface elevation of Miner Slough. This creates seepage pressure from Miner slough toward Ryer Island.

- The RD 501 drainage system artificially lowers groundwater levels (typically 2-3 feet bgs). The artificial lowering of groundwater levels further increases the seepage pressure from Miner Slough toward Ryer Island.

- The island interiors have been impacted by agricultural practices, such as aeration, decomposition, compaction, burning, and erosion. Extensive draining of the organic and peaty deposits for agriculture has altered much of the original surficial geologic and geomorphic character and resulted in subsidence on Prospect and Ryer Islands. Subsidence increases the hydraulic gradient from the surrounding sloughs to Prospect and Ryer Islands.

- A levee underseepage evaluation was performed as part of a larger regional levee investigation (URS, 2011) and the following key finding was made; approximately 90% of recorded underseepage-related performance problems in the Sacramento Valley and Delta occur along levees designated as having high and very high underseepage susceptibility. Of the 15 miles of levee evaluated within this study area, 14.3 miles (96%) had high to very high underseepage susceptibility.

13.3 Regional Groundwater Setting

- During the spring of 2012, regional groundwater levels in the vicinity of the Project were between 5 and -5 feet mean sea level and flow was generally from the northwest to the southeast (**Figure 7-2**) similar to predevelopment conditions.

13.4 Site Characterization and Development of Hydrogeologic Conceptual Model

- Four HUs were defined based on the 3D lithologic model; Levee, Upper Clay, Main Sand, Lower Clay.

- The Upper Clay HU on average is thinner under Ryer Island and thicker under Prospect Island (16 feet - Ryer, 25 feet - Prospect) (**Figure 8-14, Table 8-3**).

- There appears to be a correlation between the RD 501 reported seepage areas with locations of thin clay (less than 15 feet) and the presence of surface drainage ditches that further reduce the thickness of the clay in these areas. This is consistent with the URS (2009) Section 7, Flood Risk Analysis that found, through modeling, that clay blanket thicknesses of 15 feet or less have the largest impacts on underseepage. Additionally, the presence of drainage ditches excavated into thin clay blankets significantly increases underseepage.

- The Main Sand HU on average is thicker under Ryer Island and thinner under Prospect Island (38 feet - Ryer, 35 feet - Prospect) (**Figure 8-15, Table 8-3**)..

- Based on the 3D lithologic model (**Figures 8-4 through 8-7**), bathymetry (**Appendix B**), and bed sediment sample data (**Figure 8-9**), the channel bottoms of Miner Slough and DWSC are physically connected to the Main Sand HU throughout the study area. The intersections of the channel bottom and the Main Sand HU provide pathways for surface water to flow into the groundwater system. In general, these intersections in Miner Slough are adjacent to the RD 501 reported seepage areas (**Figure 8-9**).

- Based on the 3D lithologic model (**Figures 8-4 through 8-7**), geology and geomorphic maps (**Appendix A**), and trench logs (**Appendix C**), the surface of Prospect Island is not connected to the Main Sand HU (**Figure 8-10**).

- The integrity of the Upper Clay HU beneath Prospect Island is very important as it acts as a physical and hydraulic barrier. Any restoration design should take this into account.

13.5 Evaluation of Hydraulic Conductivity

13.5.1 K_{sbt} of Hydrogeologic Units

- The overall K_{sbt} GMs for the Levee, Upper Clay, and Main Sand HUs are $2x10^{-5}$ cm/s, $2x10^{-6}$ cm/s, and $3x10^{-3}$ cm/s, respectively (**Table 10-1; Figure 10-1**). **Figure 10-2** suggests that the Main Sand K_{sbt} is lowest near the east central portion of Ryer Island at CPT sounding RI-3 ($1x10^{-4}$ cm/s) and highest near the east central portion of Prospect Island near sounding PI-8B and west central portion of Ryer Island near sounding RI-4 and RIS-4 ($1x10^{-2}$ cm/s). It is important to note that all of the K_{sbt} estimates of the Main Sand HU from the 18 CPT soundings are within an order of magnitude of each other ranging from $1x10^{-3}$ to $1x10^{-2}$ cm/s with the exception of RI-3 ($1x10^{-4}$ cm/s).

13.5.2 K_{sbt} adjacent to Well-Screen Intervals

- The overall K_{sbt} GMs adjacent to well screens that intersect the Upper Clay and Main Sand HUs are $3x10^{-6}$ cm/s and $5x10^{-3}$ cm/s, respectively. The overall K_{sbt} GMs adjacent to well screens that intersect the Levee/Upper Clay and sand within the Lower Clay HUs on Prospect Island are $7x10^{-7}$ cm/s and $3x10^{-5}$ cm/s, respectively (**Table 10-2**). **Figure 10-3** suggests that the hydraulic conductivity in CPT soundings (K_{sbt}) adjacent to well screens in the Main Sand HU is lowest on the west central portion of Ryer Island near sounding RI-3/well MW 99-5 at $5x10^{-5}$ cm/s and highest on the southern portion of Prospect Island near sounding PI-1/well PI-1B at $9x10^{-2}$ cm/s.

13.5.3 Pore Pressure Dissipation Testing (K_{ppdt})

- Following data processing, it was found that the majority of the tests, 50 out of 64 tests (78%), had very rapid t_{50} times (<60 seconds) which strongly suggests that the CPT penetration is partially drained and interpretation becomes more complex (P. Robertson, personal communication, May 2, 2013) (**Table 10-3**). The only finding that can be made regarding these 50 samples is that they represent essentially silty sand to sand with K>10^{-5} cm/s.

- The remaining 14 out of 64 tests (22%) had t_{50} times >60 seconds suggesting undrained conditions which could be further analyzed (**Table 10-3**). The calculated K values for these 14 tests ranged from approximately 4x10^{-8} cm/s to 4x10^{-7} cm/s which appeared to be anomalously low in most cases. For comparison purposes, these test results were matched up to the collocated K_{sbt} data (**Figure 10-4**). In only 4 out of 14 comparisons (29%), the results matched up well to the collocated K_{sbt} data (meaning the data were within about one order of magnitude of each other). In the remaining 10 comparisons (71%), the results were well over one order of magnitude from the K_{sbt} data and not considered representative. Because the majority of the 14 K_{ppdt} results were not considered representative of the true K values of the HUs based on the K_{sbt} comparison, the K_{ppdt} results were not considered further in this study.

13.5.4 Slug Testing (K_{st})

- The overall K_{st} GMs adjacent to well screens that intersect the Main Sand HU and Lower Clay (sand) HU are 1x10^{-2} cm/s and 5x10^{-3} cm/s, respectively. **Figure 10-5** suggests that the K_{st} adjacent to well screens in the Main Sand HU is lowest on the northern portion of Prospect Island near well PI-5B at 6x10^{-3} cm/s and highest on the west central portion of Ryer Island near well MW 99-1 at 4x10^{-2} cm/s.

13.5.5 Comparison of K_{st} Estimates to K_{sbt} Estimates

- Overall, the estimated K_{st} GM for the Main Sand HU of 1x10^{-2} cm/s compares well to the CPT-derived K results including K_{sbt} GM of the Main Sand HU (3x10^{-3} cm/s) and K_{sbt} adjacent to Main Sand HU well-screen intervals (5x10^{-3} cm/s)(**Tables 10-1 and 10-2, Figure 10-6**). Furthermore, the various estimated K results for each CPT sounding also showed good comparability (**Appendix G**).

13.5.6 Comparison of K Estimates from other recent Delta Projects to the K_{sbt} Estimates from this Study

- The K ranges and values reported in recent Delta studies compare favorably to the K_{sbt} GM estimates from this study as summarized below:
    - Prospect-Ryer Island Levee HU: 2x10^{-5} cm/s
    - Prospect-Ryer Island Upper Clay HU: 2x10^{-6} cm/s

- Prospect-Ryer Island Main Sand HU: $3x10^{-3}$ cm/s

13.5.7 Bed Sediment Samples

- Of the 25 samples that were laboratory tested, 22 samples (88%) had estimated K values that were consistent with the field textural descriptions (**Table 8-2**). Three of 25 samples (12%) had estimated K values that were not consistent with the field textural descriptions; all of these samples were described in the field as silty sand.

- Of the 11 samples collected from the center line and deep spots along Miner Slough, eight had coarse-grained textures (~73%). Of the three samples collected from the center line of the DWSC, three had coarse-grained textures (100%). Overall, 21 out of 32 bed sediment samples (~66%) had coarse-grained textures which suggests that the majority of the bed sediments in the study area are sandy in nature and have high K values.

13.6 Surface water and Groundwater Data Analysis

- Prospect Island

  - Overall, the data indicate that there is a significant hydraulic connection between the DWSC, Miner Slough, and the Main Sand HU due to the physical connection between the channel bottoms of DWSC and Miner Slough and the Main Sand HU (**Figure 8-9**).

  - Prospect Island site hydrographs (**Figures 11-1 through 11-28**) indicate that stage on Prospect Island is influenced by local precipitation and stage in Miner Slough and the DWSC.

  - Hydrographs show a generally downward vertical hydraulic gradient from the DWSC and Miner Slough to Prospect Island, which indicates that the DWSC and Miner Slough are predominantly losing streams in the study area.

  - There is an upward vertical hydraulic gradient from the Main Sand HU to the Upper Clay HU along the western edge of Prospect Island due to the physical connection of the DWSC to the Main Sand HU (**Figure 8-9**). There is a downward vertical hydraulic gradient from the Upper Clay HU to the Main Sand HU along the eastern edge of Prospect Island.

- Ryer Island
  - Overall, the data indicate that there is a significant hydraulic connection between Miner Slough and the Main Sand HU due to the physical connection between the channel bottom of Miner Slough and the Main Sand HU (**Figure 8-9**).
  - Ryer Island site hydrographs (**Figures 11-29 through 11-43**) indicate that groundwater levels on Ryer Island are significantly influenced by local precipitation and stage in Miner Slough.
  - Hydrographs show a significant vertical hydraulic gradient from Miner Slough to Ryer Island which indicates that Miner Slough is a losing stream in the study area. There is an upward vertical hydraulic gradient from the Main Sand HU to the Upper Clay HU at all monitoring well sites.
  - During the winter and early spring, groundwater levels are close to or above the ground surface elevation on Ryer Island. These conditions coincide with precipitation events, stage increases in Miner Slough, and potentially the seasonal change in drainage system operation, which needs to be further evaluated. This is significant because when groundwater levels in the shallow aquifer system rise to within a foot or less from the ground surface, agricultural activities may be affected due to the saturation of shallow-depth, clay-rich soils. Also, when groundwater levels in the shallow aquifer system rise above the ground surface, groundwater seepage occurs. Furthermore, when the shallow groundwater levels are close to or above the ground surface, any precipitation that occurs will result in ponding.
  - During the spring and summer, the groundwater levels on Ryer Island decrease up to several feet and this is likely due to the operation of the Ryer Island drainage system which lowers shallow groundwater levels in order to create a seasonal unsaturated zone to grow crops. Additionally, groundwater levels in wells MW 99-2, -4, -5, -6, -7, and -8 show small increases during the spring and summer which are likely caused by irrigation activities.
- Seepage Transect Hydrographs
  - Hydrographs indicate that the groundwater levels in the Main Sand HU near the seepage transects respond to Miner Slough stage and attenuate to the

east beneath Ryer Island. In the north and middle transects, groundwater in the Main Sand HU flows from Miner Slough to the east beneath Ryer Island.

- Groundwater levels, and to a limited extent drainage ditch stage, appear to correspond to Miner Slough stage. There are also fluctuations in drainage ditch stage that do not correspond to groundwater level changes, and these are likely caused by irrigation activities on Ryer Island. Additionally, there was a precipitation event that occurred on September 21, 2013 and a small response was observed in West Canal and Elkhorn Slough 1. As additional data are collected at these locations, the interaction between drainage ditch stage and groundwater levels will be further evaluated.

- Based on the 3D lithologic model, bathymetry, bed sediment samples, and hydrograph data, the channel bottoms of Miner Slough and DWSC are physically and hydraulically connected to the Main Sand HU throughout the study area. The intersections of the channel bottom and the Main Sand HU provide pathways for surface water to flow into the groundwater system. In general, these intersections in Miner Slough are adjacent to the RD 501 reported seepage areas (**Figure 8-9 and Appendix B**).

- Potentiometric surface contour maps for the summer and winter 2012 periods indicate that Miner Slough is the dominant hydrologic feature controlling groundwater flow within the study area.

13.7 Seepage Modeling Analysis

- The seepage analysis shows little to no variation in total head under the Ryer Island Levee, 0.14 feet or less from past to existing scenarios and 0.04 feet or less from existing to restored scenarios (**Table 12-3**).

- The seepage analysis shows little to no variation in groundwater flow under the Ryer Island Levee, 1.1% or less from past to existing scenarios and 0.3% or less from existing to restored scenarios (**Table 12-4**).

- Regardless of the conditions on Prospect Island (dry or flooded) the total head and groundwater flow under the Ryer Island levee show little to no change. Therefore, the Project should have little to no seepage effects on Ryer Island.

- The groundwater flow under the Ryer Island levee is directly related to the stage in Miner Slough. The modeled flow increases an estimated 50 to 70% from average conditions (5 feet NAVD88) to high-stage conditions (10 feet NAVD88). This suggests that the source of seepage on Ryer Island is from Miner Slough and seepage flow increases with higher Miner Slough stage.

14.0 RECOMMENDATIONS

- Data collection at Ryer Island monitoring wells MW 99-9 and -10 was discontinued on February, 2012 at the request of the land owner. This caused a hydrologic data gap in the northwest portion of Ryer Island. Reestablishment of monitoring wells in this area would be beneficial.

- Further exploration of the connection between the Miner Slough channel bottom and the subsurface hydrogeology may be useful.

- Operation of the RD 501 drainage system affects shallow groundwater levels on Ryer Island. The standard operating procedures of the drainage system need to be further evaluated.

- The existing monitoring well network on Prospect and Ryer Island should be monitored consistently throughout all future phases of the Project.

- The spatial and temporal extent of the RD 501 reported seepage areas needs to be better defined.

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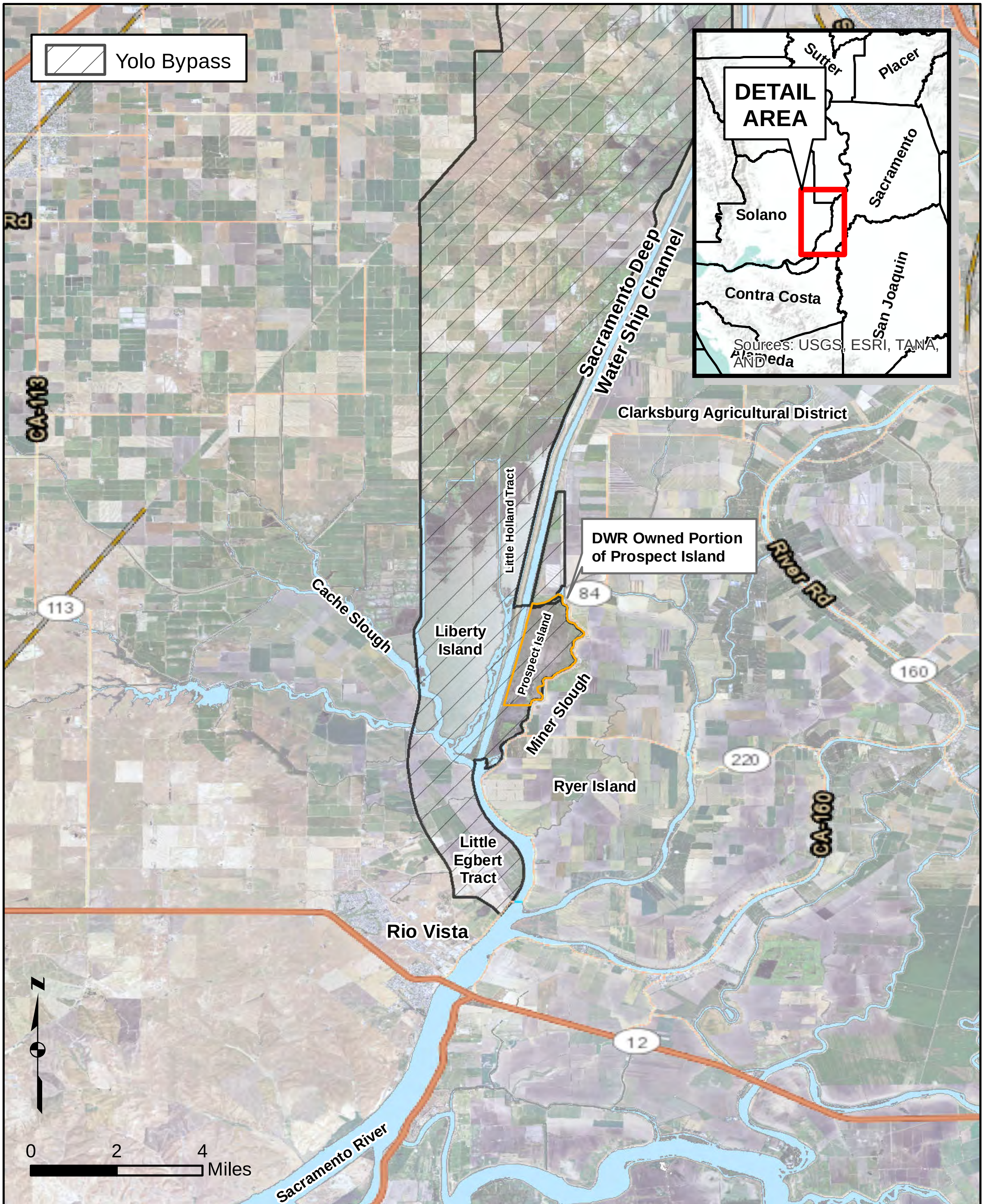
Figures



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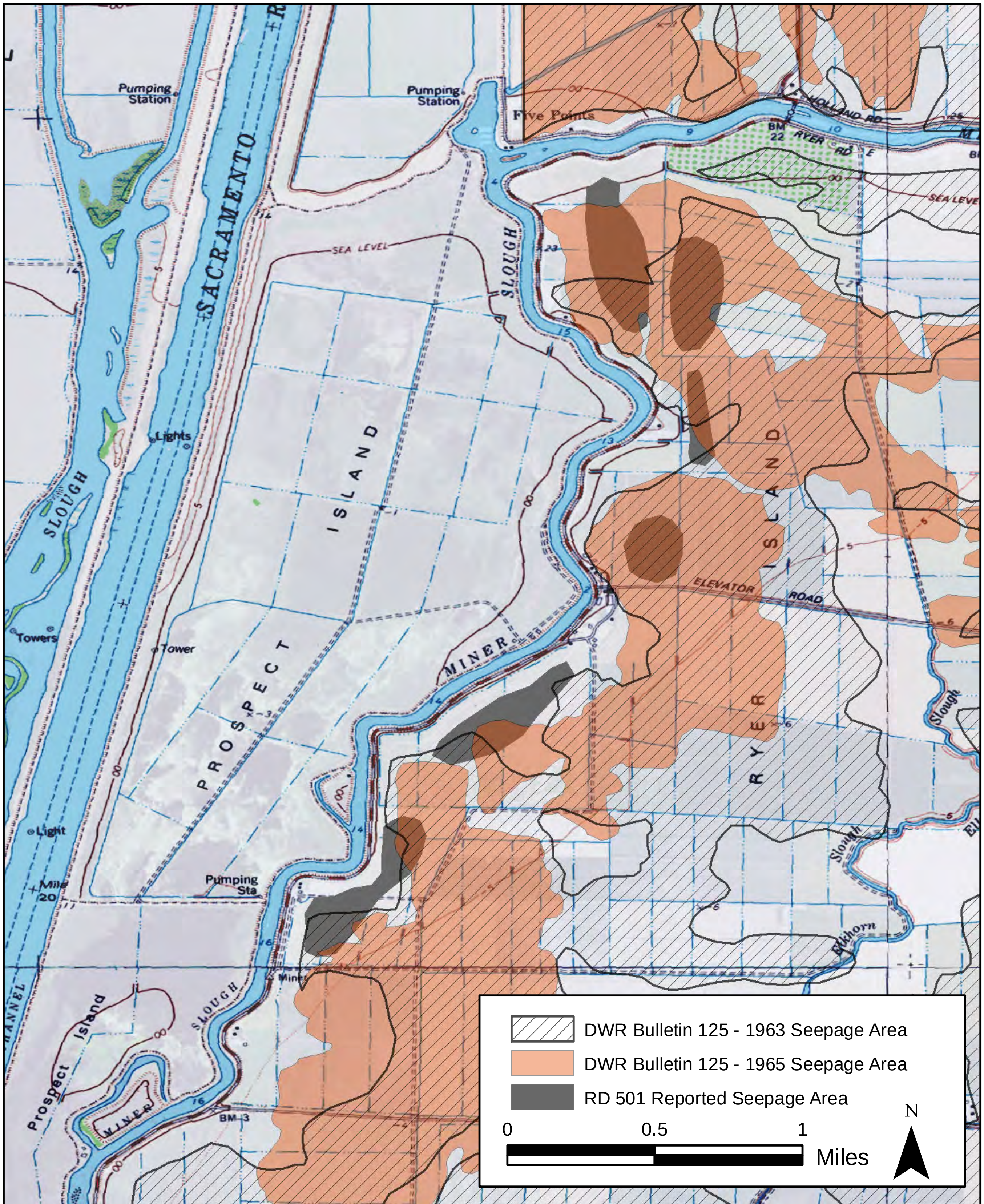
Prospect Island
Tidal Habitat Restoration Project
Location Map

Figure 4-1



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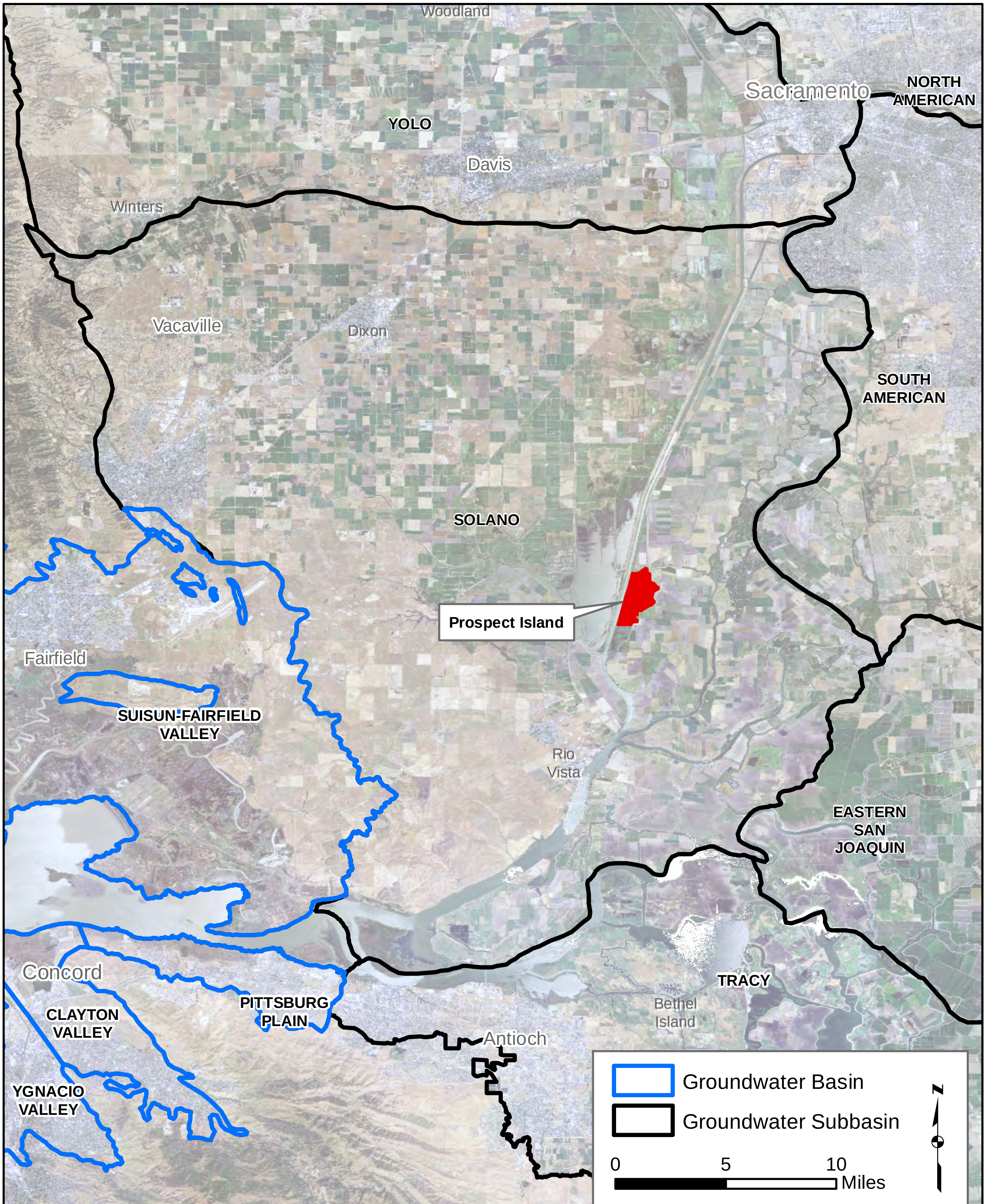
Sacramento Valley Seepage Investigation DWR Bulletin No. 125 with RD 501 Reported Seepage Areas

Figure 5-1



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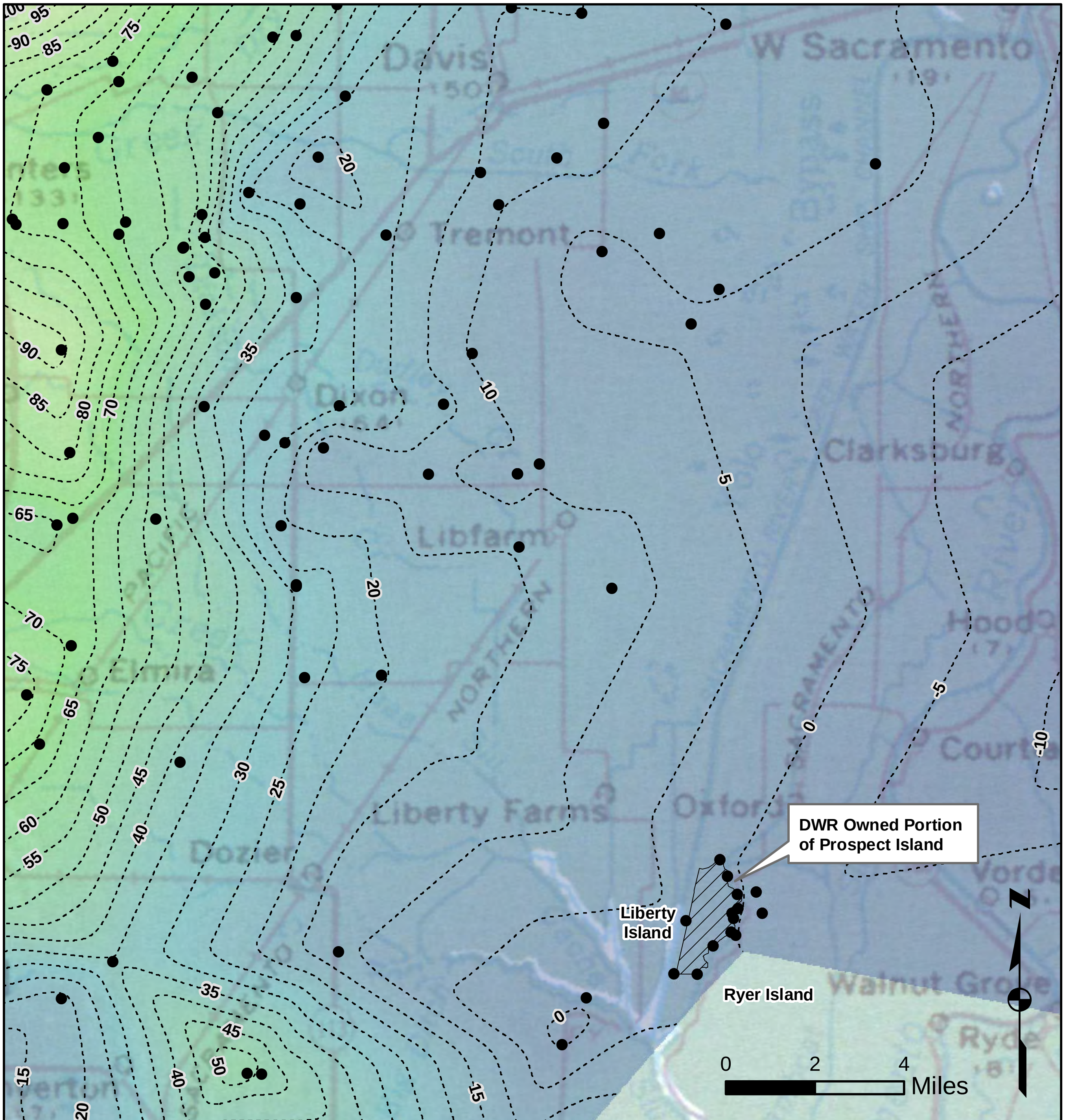
Regional Groundwater Setting

Figure 7-1



● Spring 2012 Groundwater Contour Data Point

25 -------- Potentiometric contour - Shows elevation of the Spring 2012 potentiometric surface, in feet NAVD88. Contour interval is 5 feet.

Potentiometric Surface (ft, NAVD88)

High : 109.5

Low : -11.6

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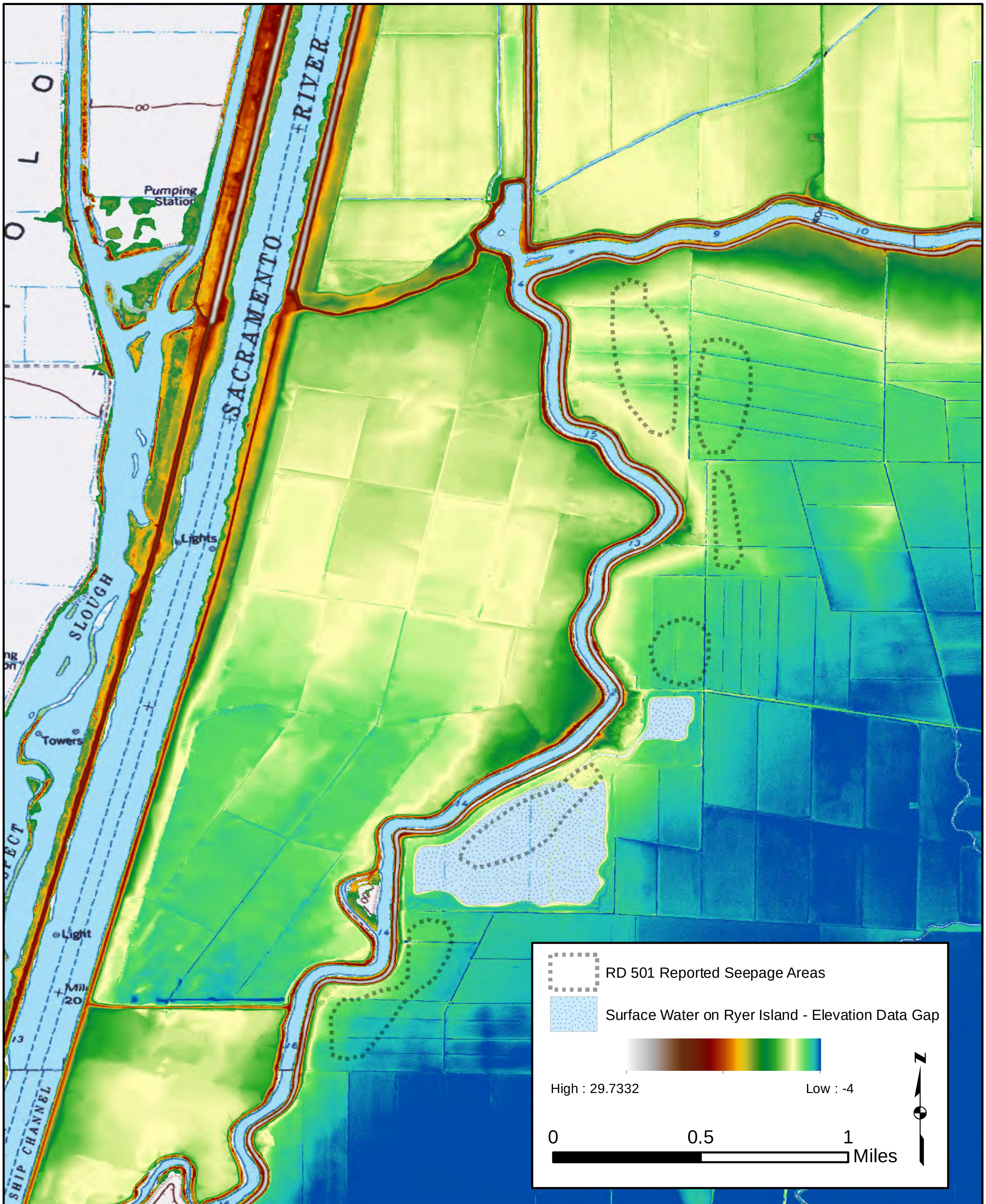
Regional Groundwater Contour Map

Figure 7-2



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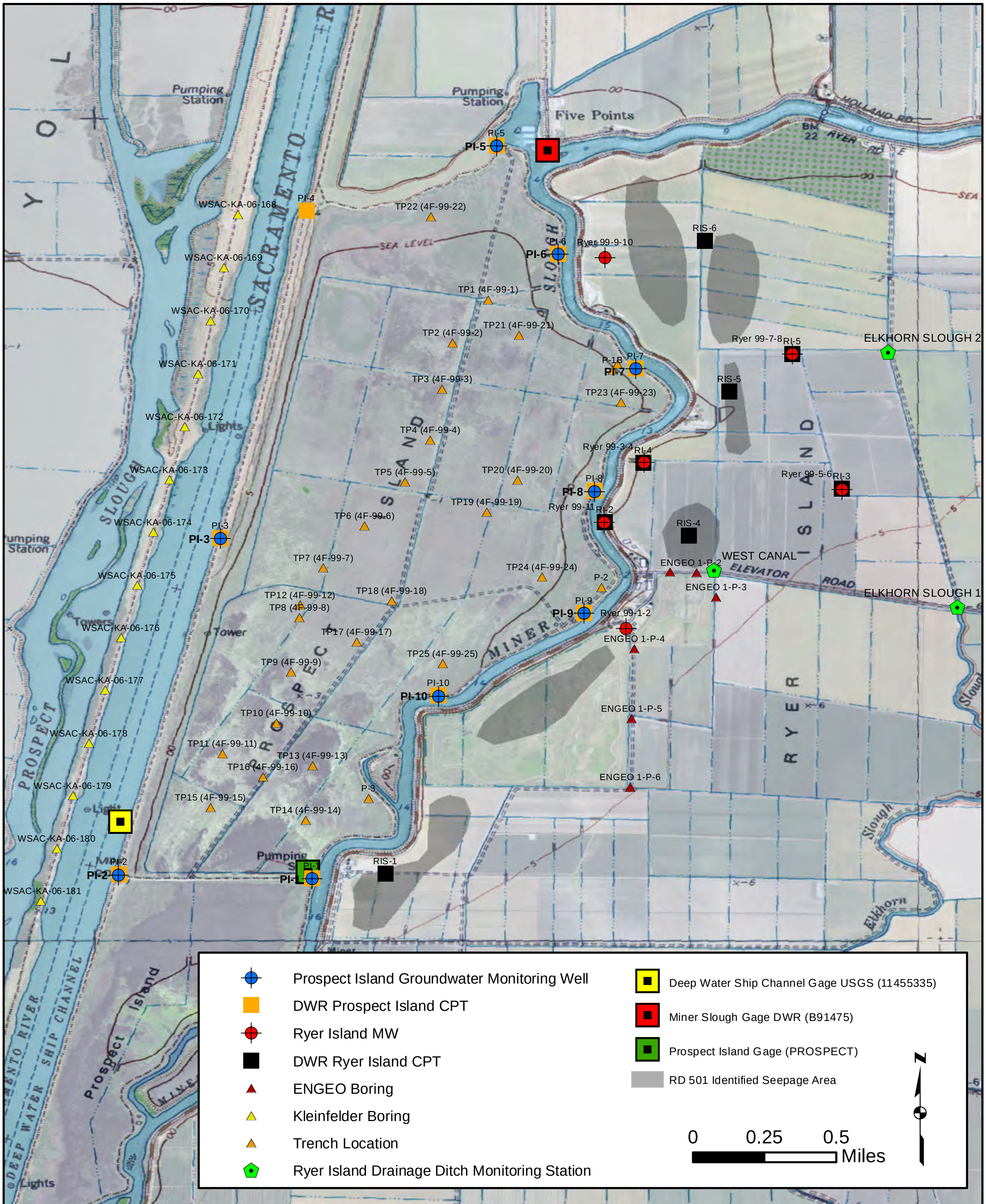
Study Area
Digital Elevation Model

Figure 8-1



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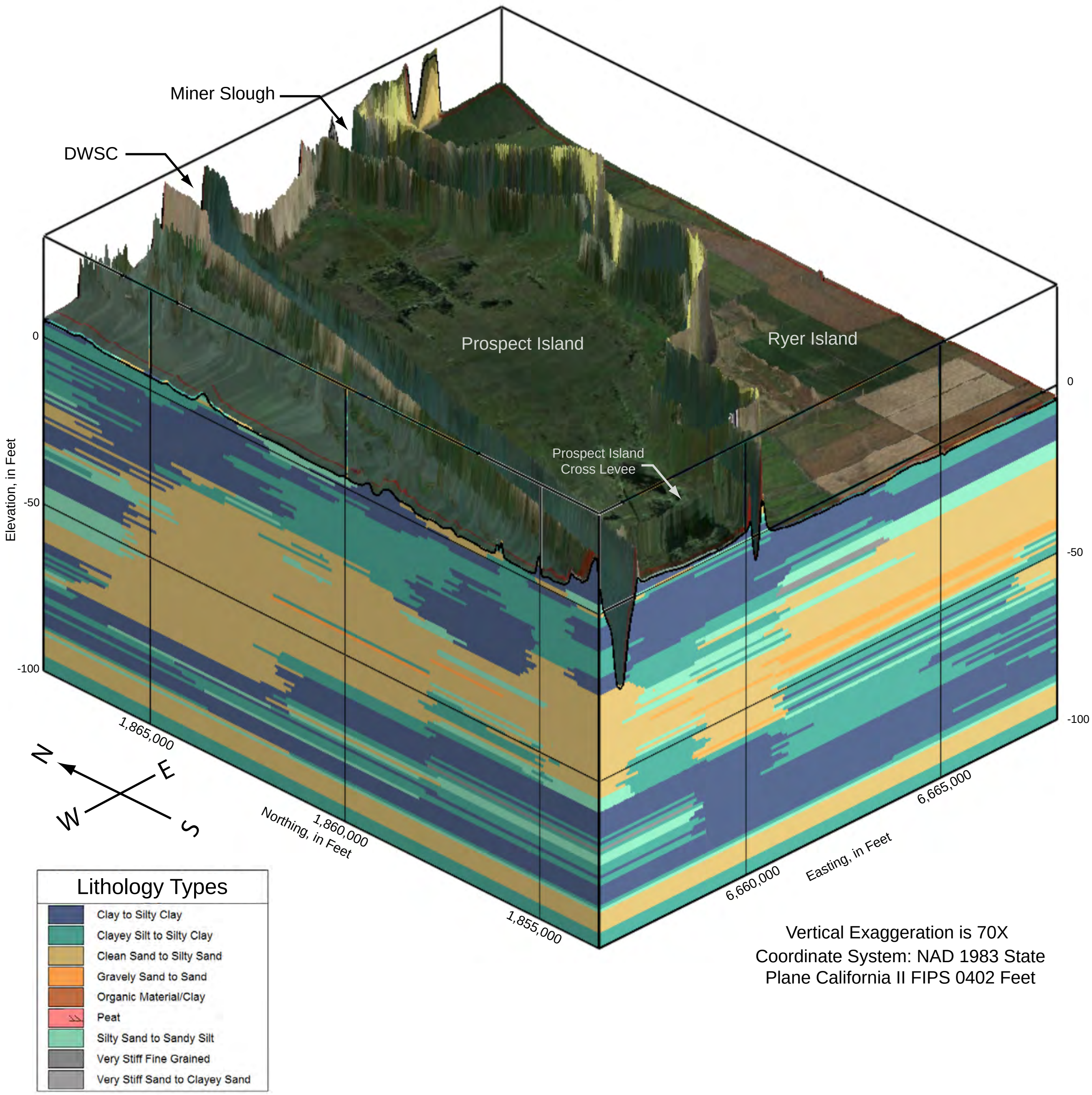
Subsurface Explorations and Surface Water and Groundwater Monitoring Locations

Figure 8-2



DEPARTMENT OF WATER RESOURCES Division of Integrated Regional Water Management NORTH CENTRAL REGION OFFICE *Geology and Groundwater Investigations Section*	**3D Lithologic Model**	**Figure 8-3**

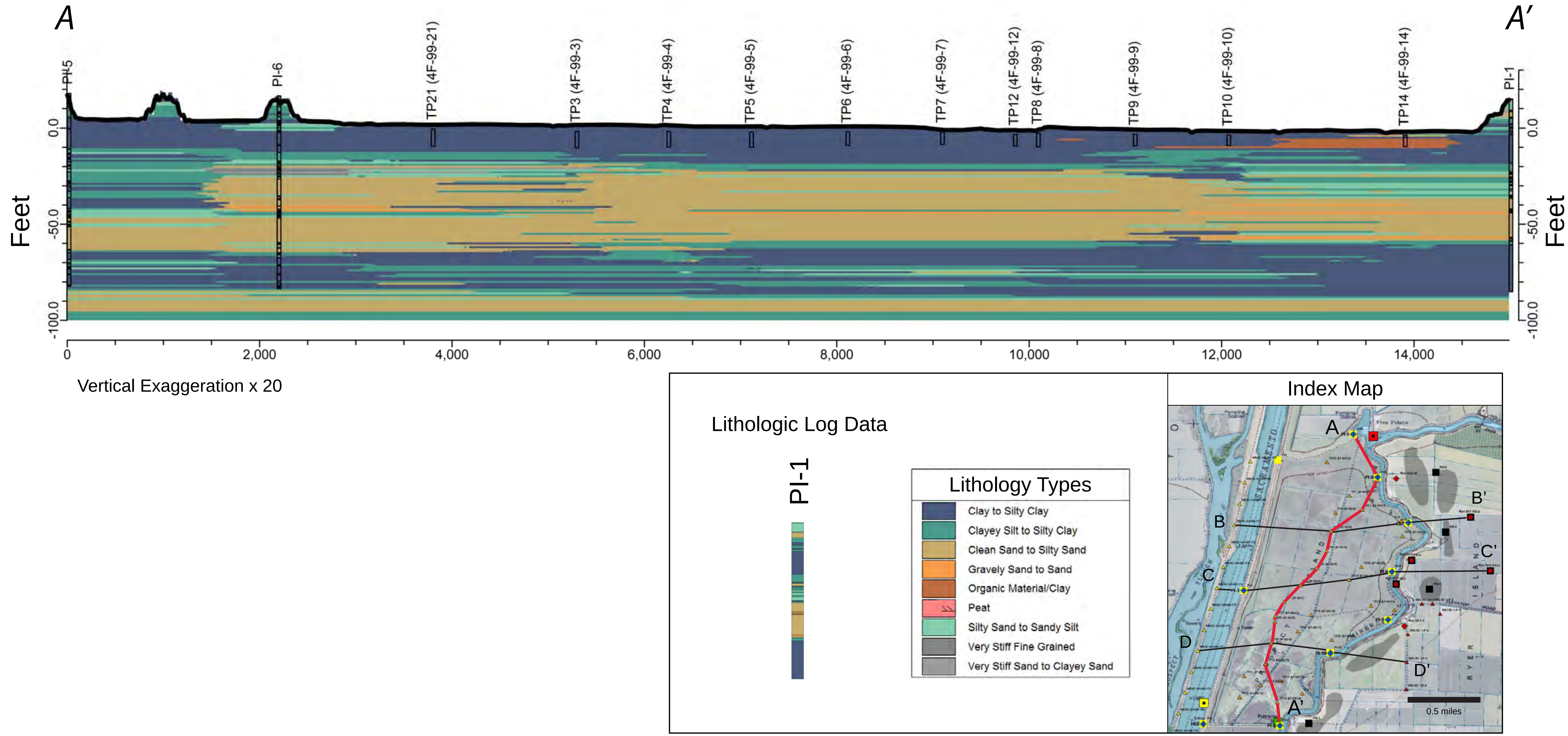


Figure 8-4. Three-dimensional (3D) solid volume lithology model results for section A - A′. Lithologic logs are shown along the section line.

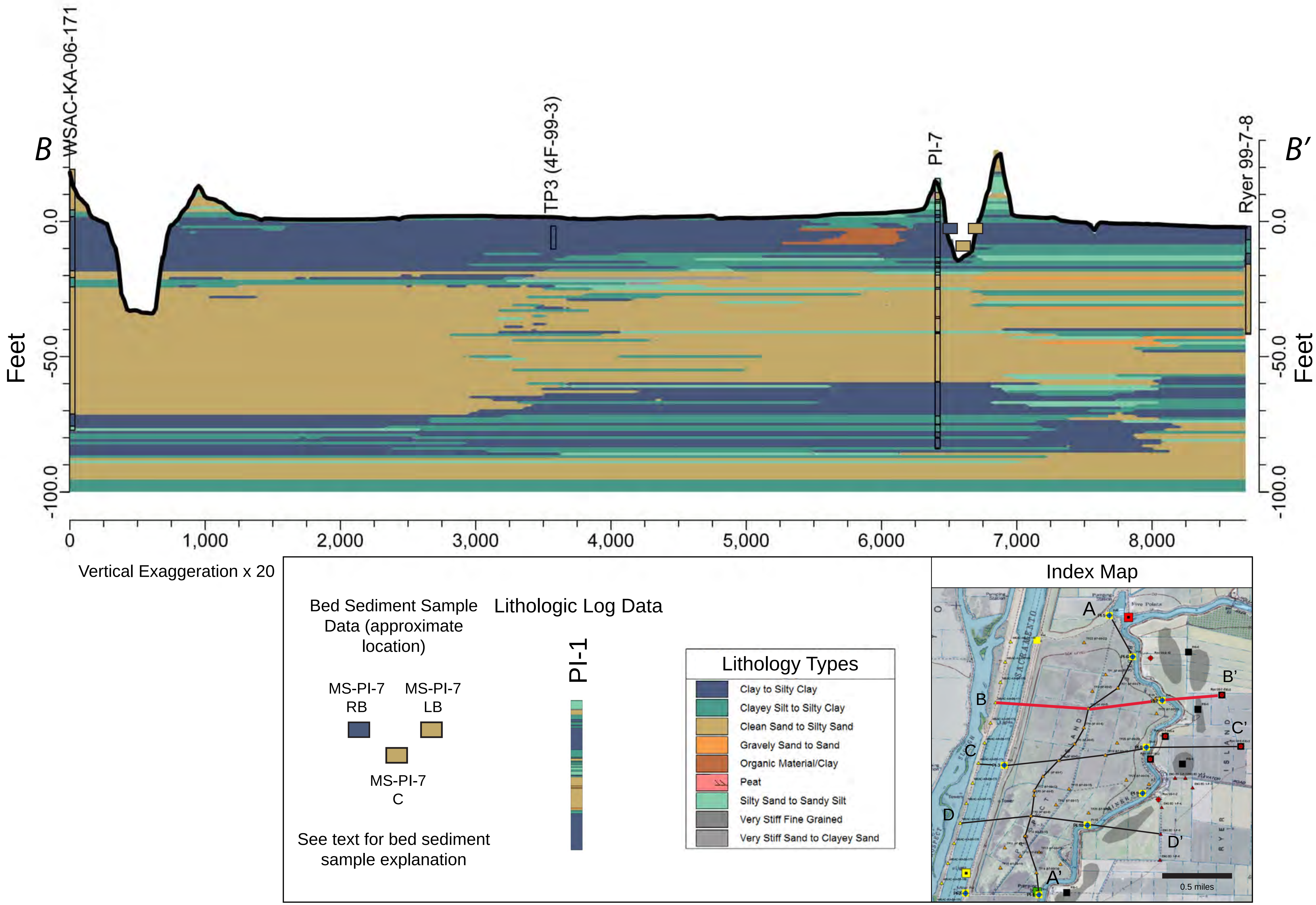


Figure 8-5. Three-dimensional (3D) solid volume lithology model results for section B - B'. Lithologic logs are shown along the section line.

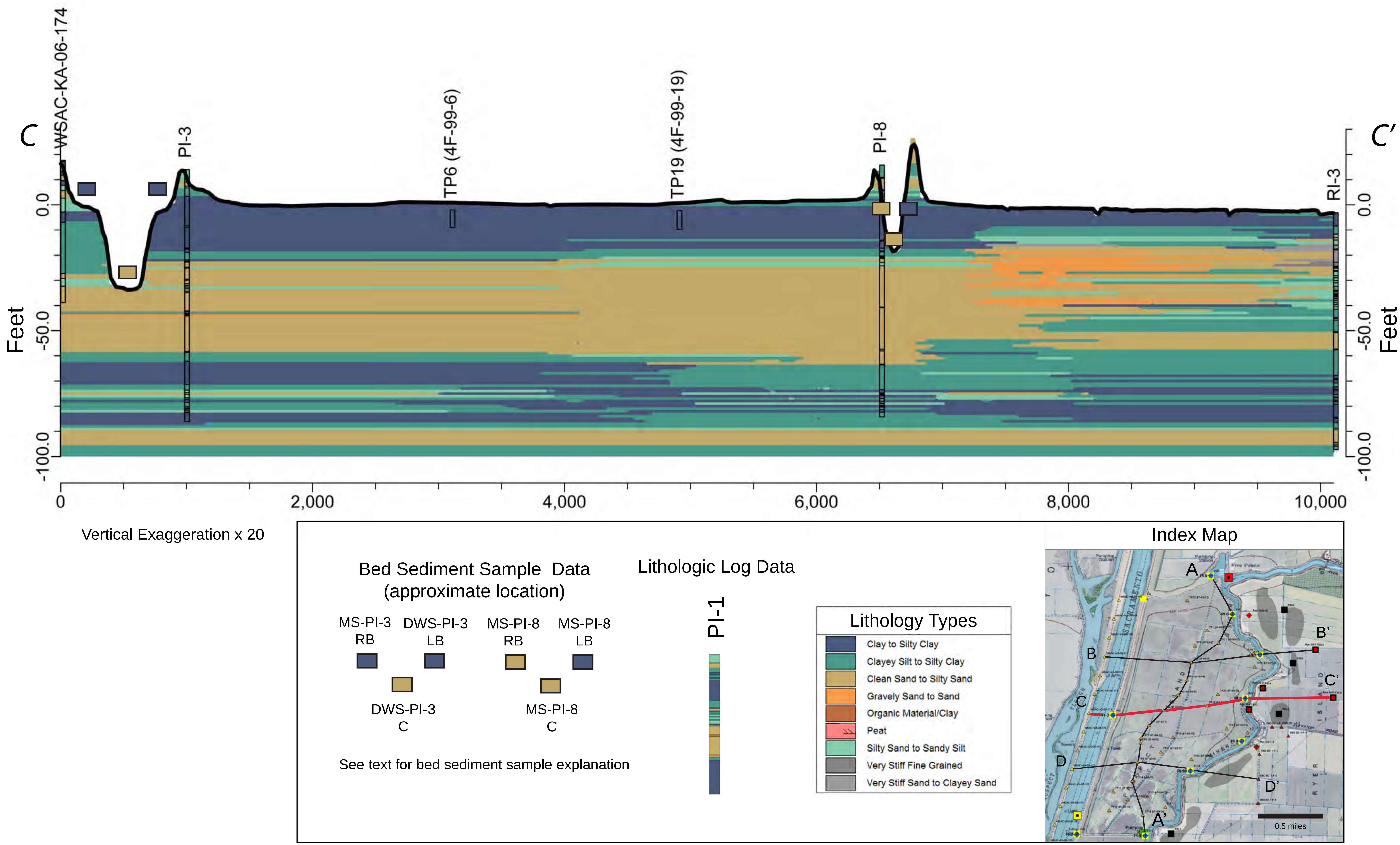


Figure 8-6. Three-dimensional (3D) solid volume lithology model results for section C -C'. Lithologic logs are shown along the section line.

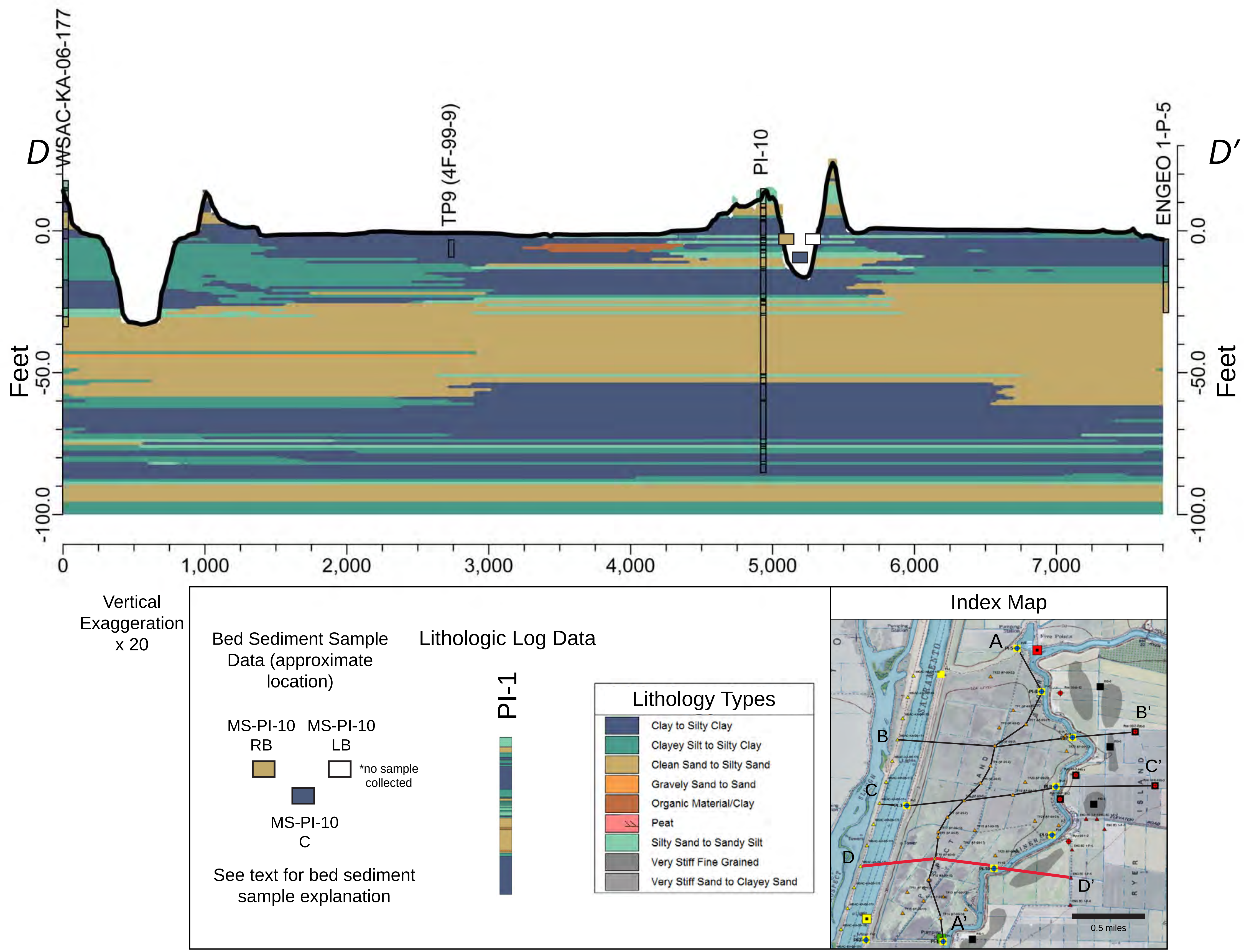
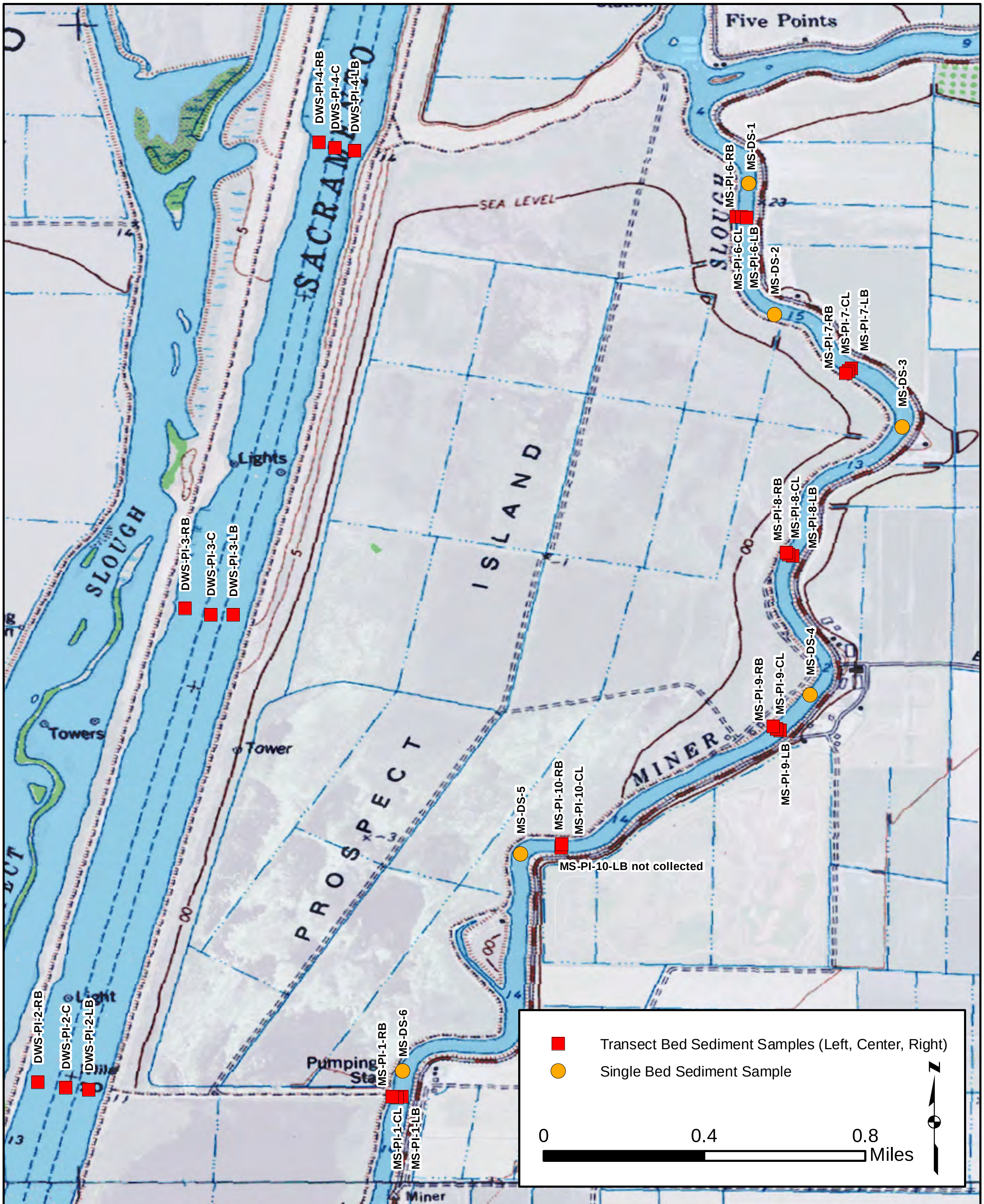


Figure 8-7. Three-dimensional (3D) solid volume lithology model results for section D - D’. Lithologic logs are shown along the section line.



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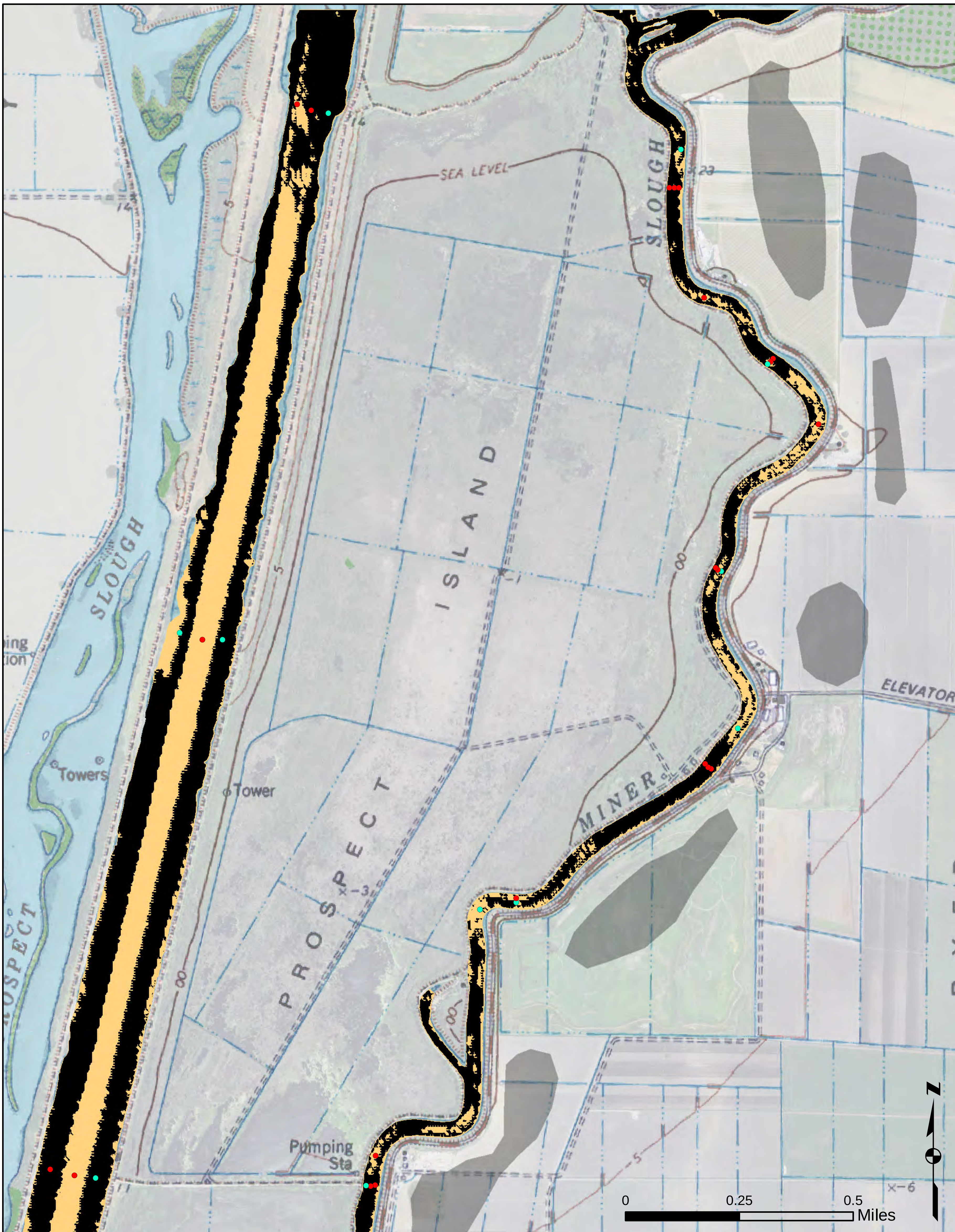
Miner Slough and Sacramento Deep Water Ship Channel Bed Sediment Sample Locations

Figure 8-8



Estimated Channel Bottom Lithology from 3D model

Coarse Grained Texture
- Silty Sand to Sandy Silt
- Clean Sand to Silty Sand
- Gravely Sand to Sand

Fine Grained Texture
- Organic Clay
- Clay to Silty Clay
- Clayey Silt to Silty Clay
- Very Stiff Fine Grained
- Very Stiff Sand to Clayey Sand

Miner Slough and DWSC Bed Sediment Samples

- CLAY; SANDY CLAY; SANDY CLAY WITH ORGANICS
- SAND; SAND AND GRAVEL; SILTY SAND

RD 501 Reported Seepage Area

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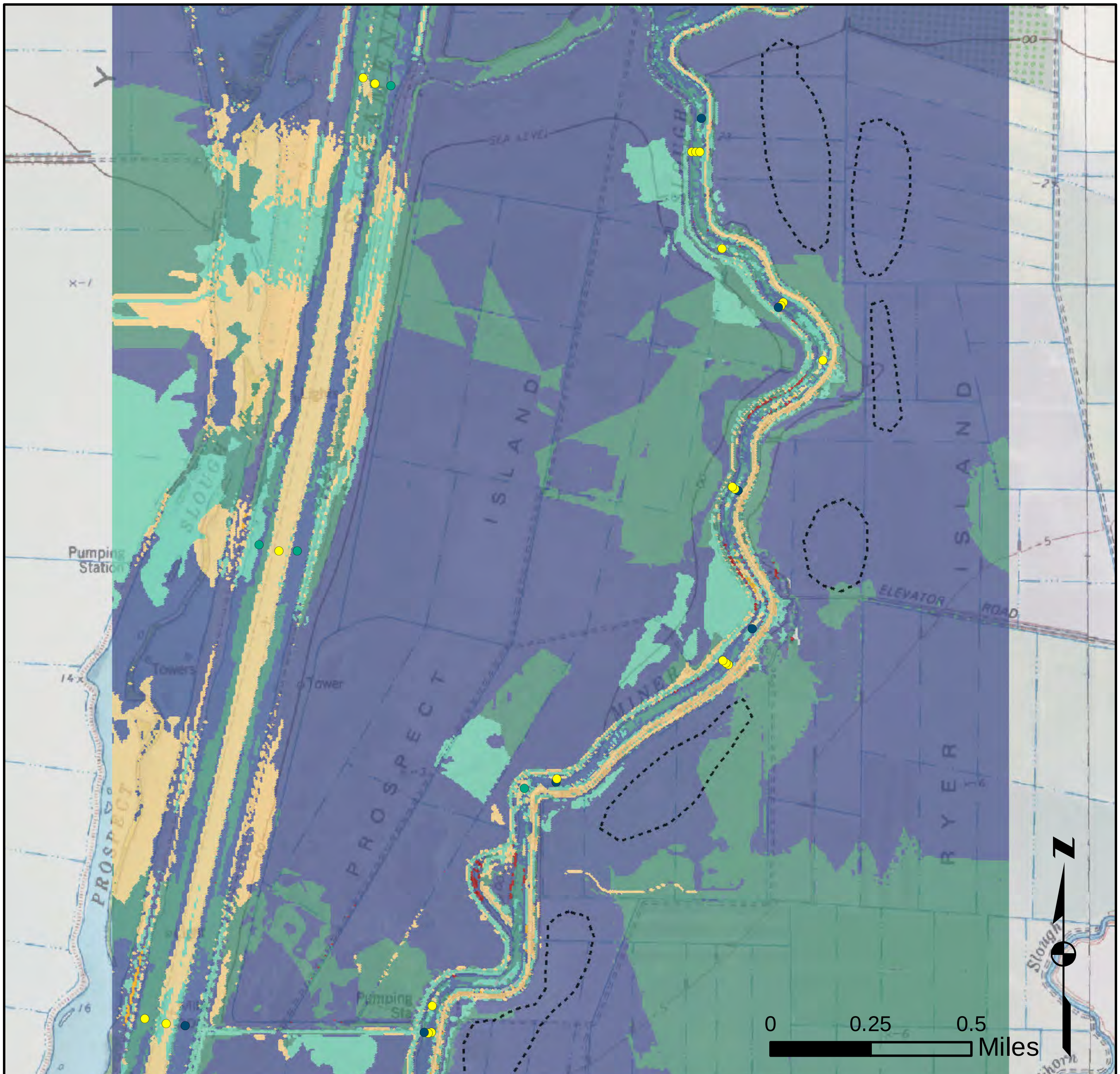
Estimated Channel Bottom Lithology From 3D Model and Bed Sediment Samples

Figure 8-9



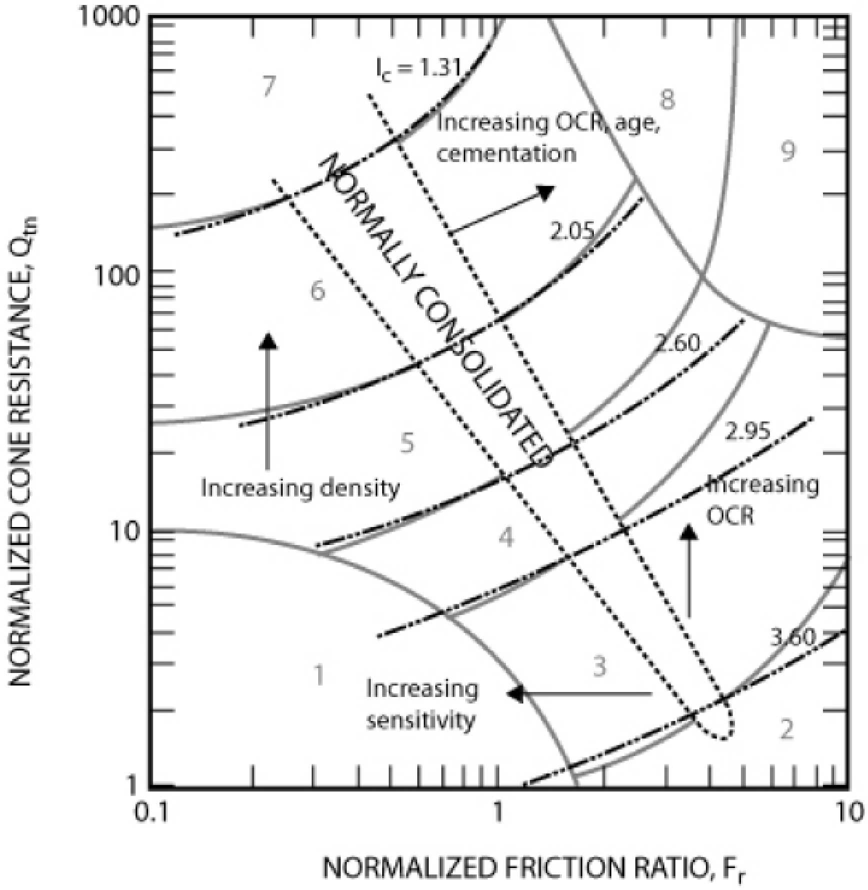
Miner Slough and DWSC Bed Sediment Samples

- CLAY
- SANDY CLAY; SANDY CLAY WITH ORGANICS
- SAND; SAND AND GRAVEL; SILTY SAND
- RD 501 Reported Seepage Areas

Estimated Surface Lithology from 3D model

- Organic Clay
- Clay to Silty Clay
- Clayey Silt to Silty Clay
- Silty Sand to Sandy Silt
- Clean Sand to Silty Sand
- Gravely Sand to Sand
- Very Stiff Sand to Clayey Sand
- Very Stiff Fine Grained

DEPARTMENT OF WATER RESOURCES Division of Integrated Regional Water Management NORTH CENTRAL REGION OFFICE Geology and Groundwater Investigations Section	**Estimated Surface Lithology From 3D Model and Bed Sediment Samples**	**Figure 8-10**

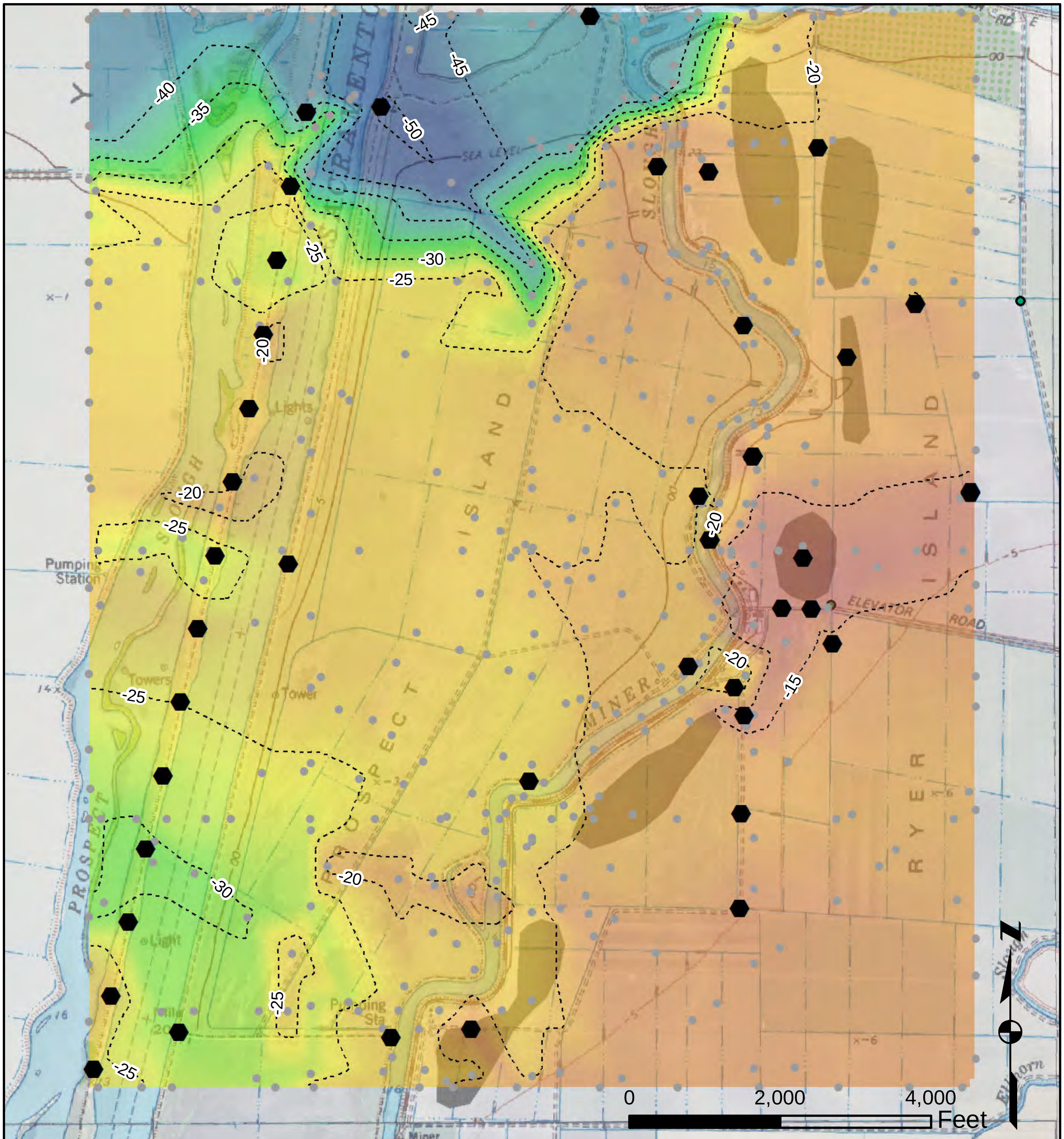


Zone	*Soil Behavior Type*	I_c
1	*Sensitive, fine grained*	N/A
2	*Organic soils – clay*	> 3.6
3	*Clays – silty clay to clay*	2.95 – 3.6
4	*Silt mixtures – clayey silt to silty clay*	2.60 – 2.95
5	*Sand mixtures – silty sand to sandy silt*	2.05 – 2.6
6	*Sands – clean sand to silty sand*	1.31 – 2.05
7	*Gravelly sand to dense sand*	< 1.31
8	*Very stiff sand to clayey sand**	N/A
9	*Very stiff, fine grained**	N/A

* *Heavily overconsolidated or cemented*

from Robertson, 1990, updated by Robertson, 2010)

DEPARTMENT OF WATER RESOURCES Division of Integrated Regional Water Management NORTH CENTRAL REGION OFFICE *Geology and Groundwater Investigations Section*	**Normalized CPT Soil Behavior Type (SBTn) Chart**	**Figure 8-11**



Datapoint From CPT or Geotech Boring

Datapoint From 3D Lithology Model

RD 501 Reported Seepage Areas

Structure Contour - Top of Main Sand (ft, NAVD88). Contour interval is 5 ft.

Elevation of Top Main Sand in feet NAVD88

High: -10

Low: -51

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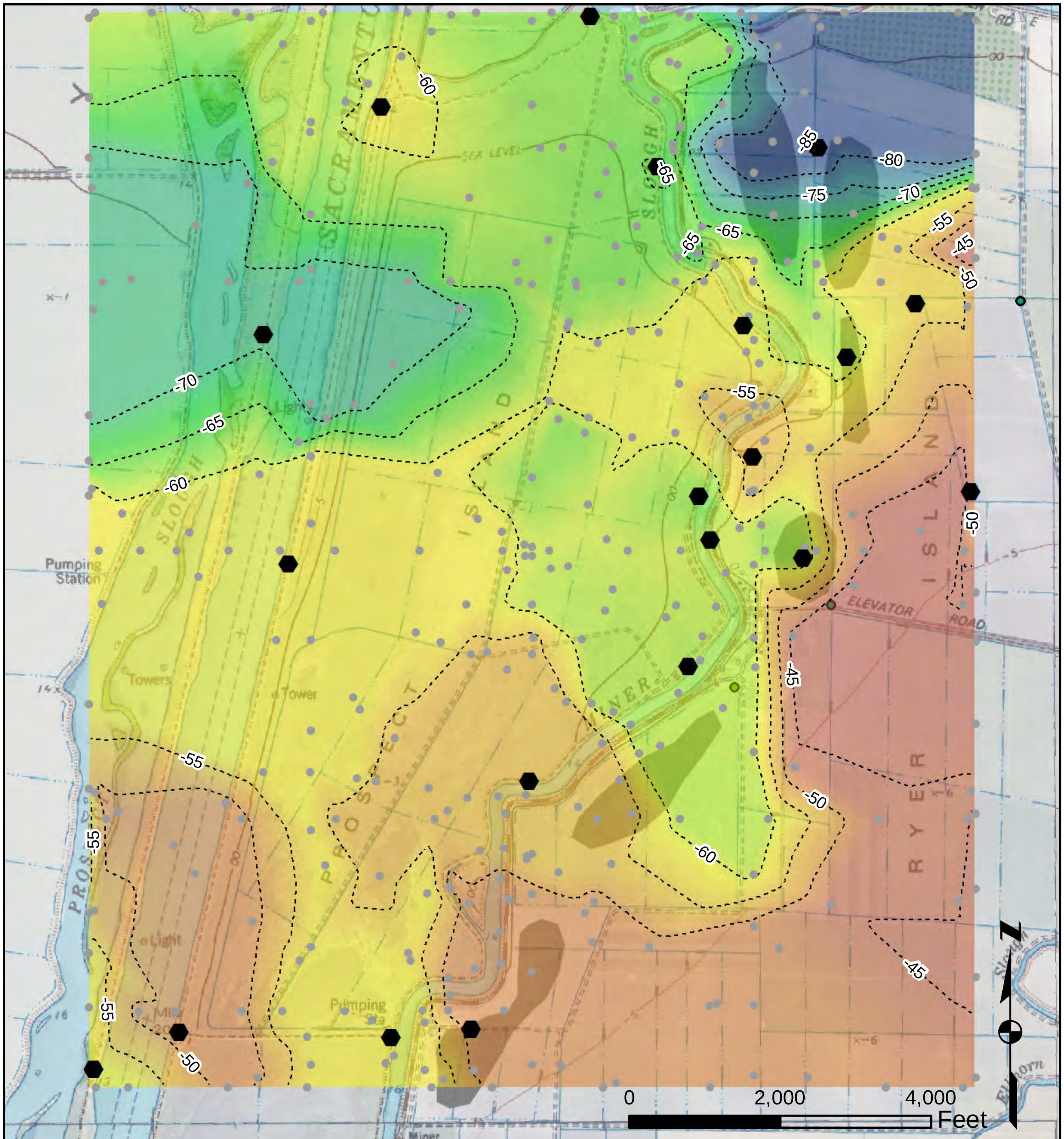
Top of Main Sand Structure Contour Map

Figure 8-12



Datapoint From CPT or Geotech Boring

Datapoint From 3D Lithology Model

RD 501 Reported Seepage Areas

Structure Contour - Base of Main Sand (ft, NAVD88). Contour interval is 5 ft.

Elevation of Base Main Sand in feet NAVD88

High : -42

Low : -86

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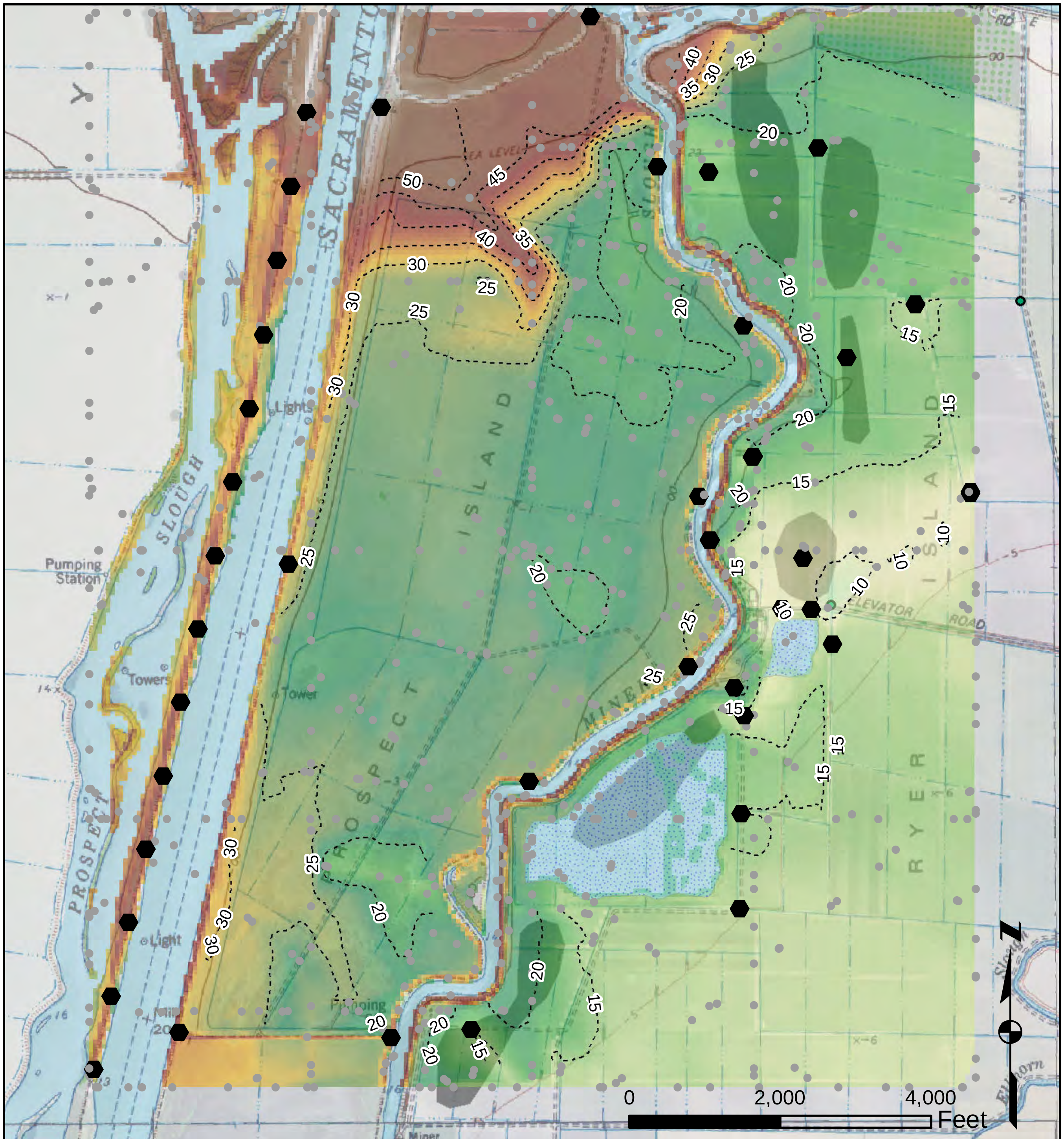
Base of Main Sand Structure Contour Map

Figure 8-13



Datapoint From CPT or Geotech Boring

Datapoint From 3D Lithology Model

Surface Water on Ryer Island - Elevation Data Gap

RD 501 Reported Seepage Areas

Thickness of Upper Clay in feet. Contour interval is 5 feet

Thickness of Upper Clay in feet

High : 73.8126

Low : 0

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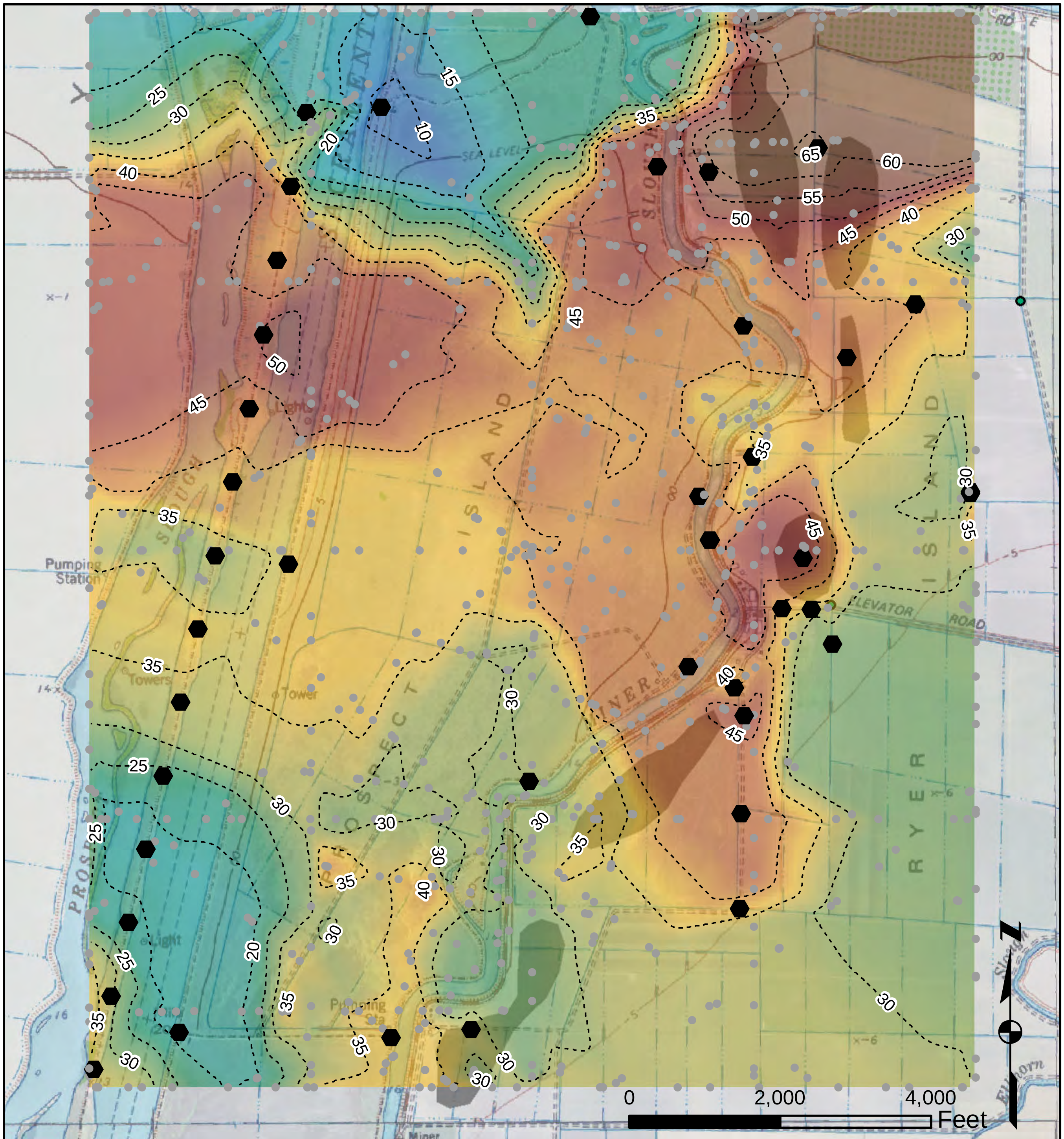
Thickness Map - Upper Clay

Figure 8-14



Datapoint From CPT or Geotech Boring

Datapoint From 3D Lithology Model

RD 501 Reported Seepage Areas

Thickness of Main Sand in feet. Contour interval is 5 feet.

Thickness of Main Sand in feet

Thick: 66

Thin: 8

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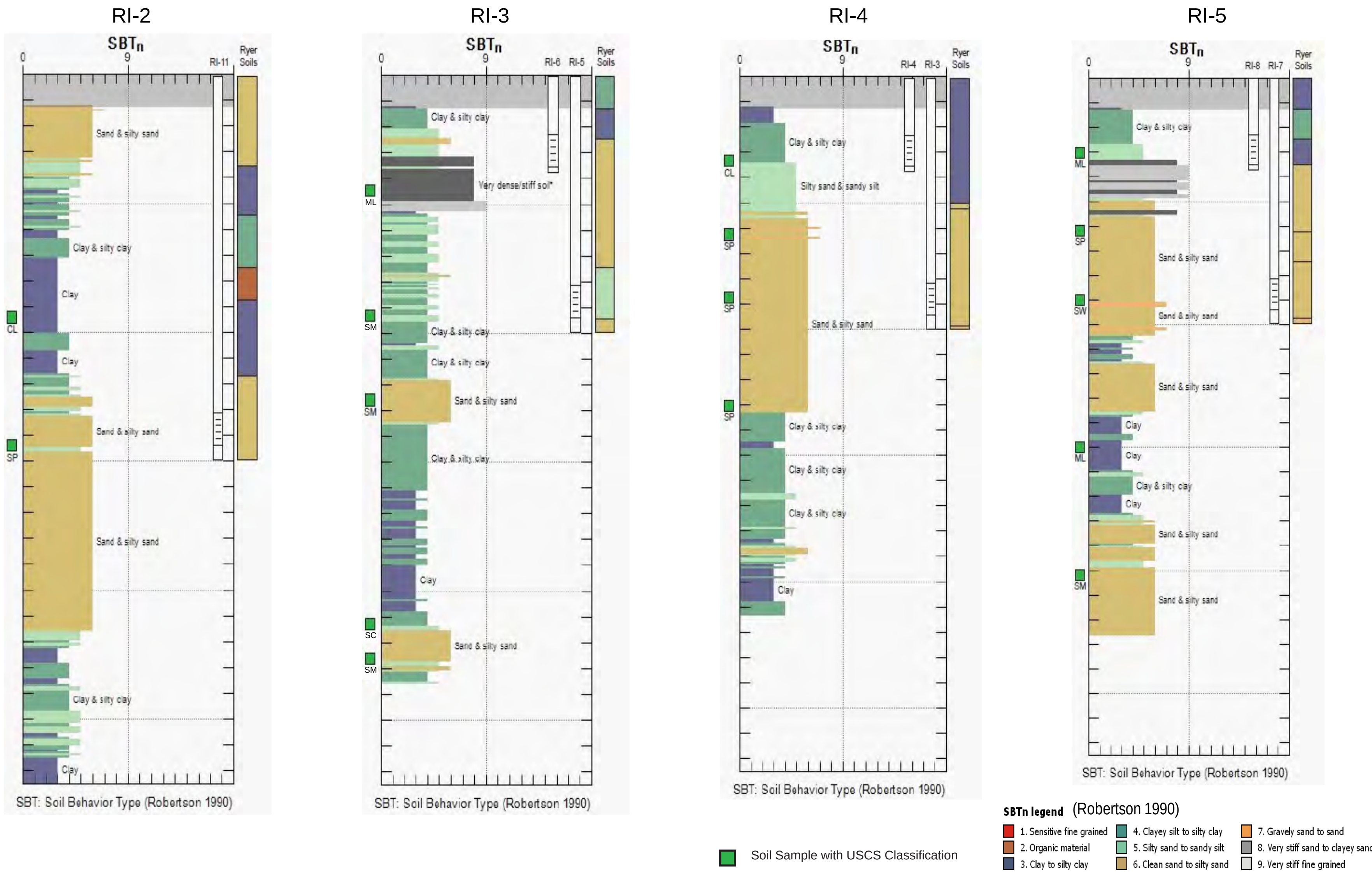
Thickness Map - Main Sand

Figure 8-15



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Comparison of SBTn Results to Ryer Island Well Boring Stratigraphy

Figure 9-1

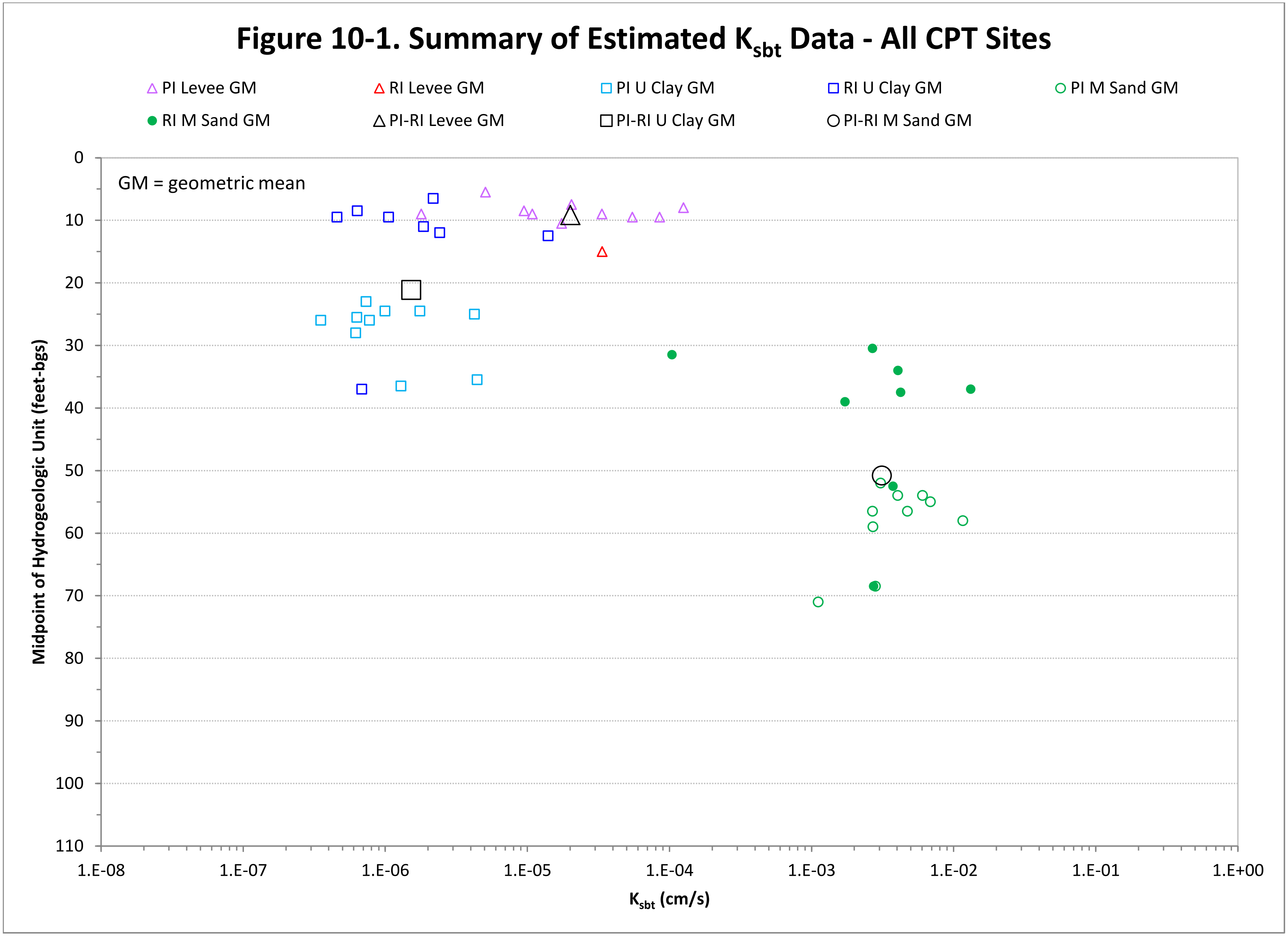
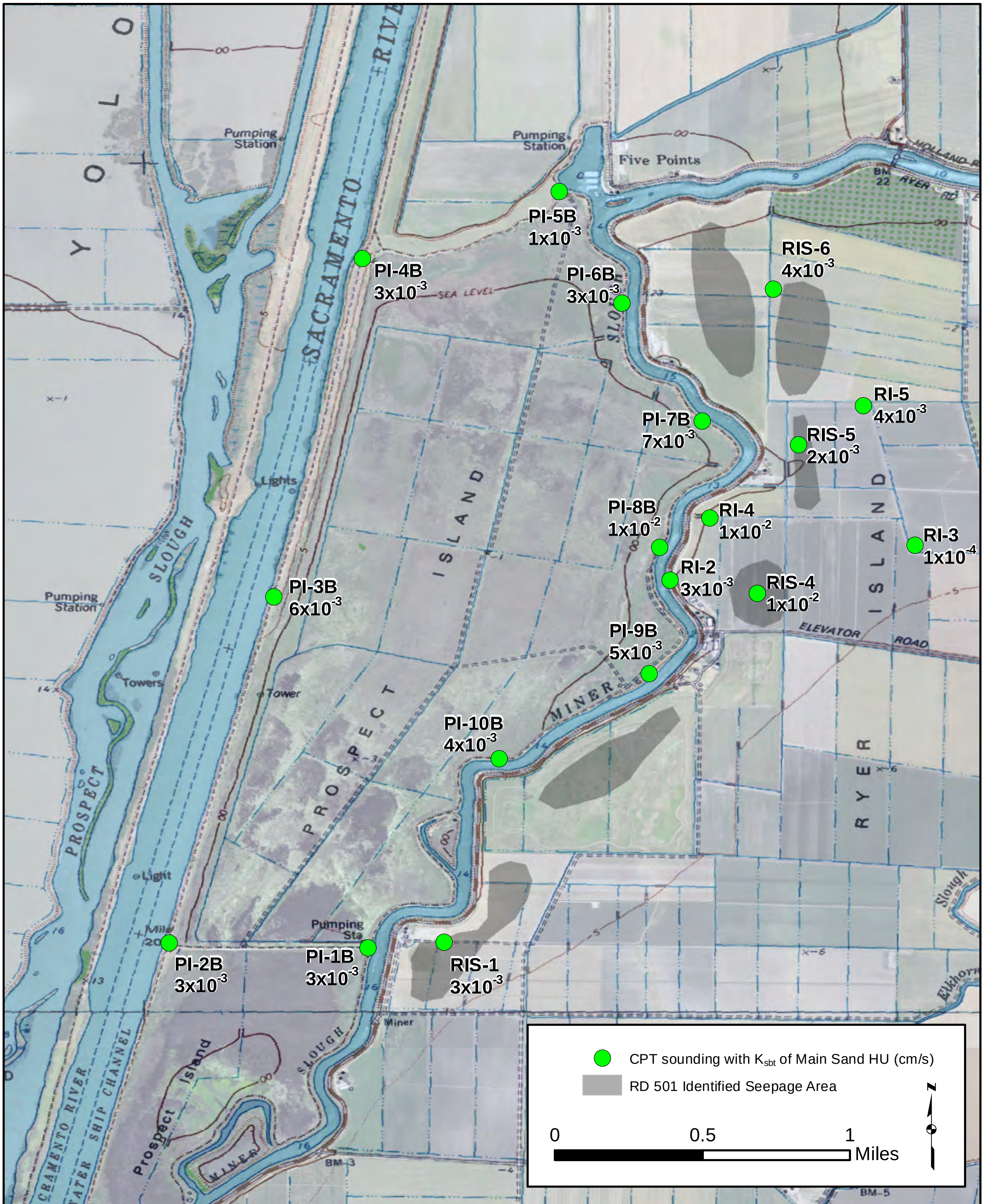


Figure 10-1. Summary of Estimated K_{sbt} Data - All CPT Sites
PI Levee GM
RI Levee GM
PI U Clay GM
RI U Clay GM
PI M Sand GM
RI M Sand GM
PI-RI Levee GM
PI-RI U Clay GM
PI-RI M Sand GM
GM = geometric mean
Midpoint of Hydrogeologic Unit (feet-bgs)
0
10
20
30
40
50
60
70
80
90
100
110
1.E-08
1.E-07
1.E-06
1.E-05
1.E-04
1.E-03
1.E-02
1.E-01
1.E+00
K_{sbt} (cm/s)



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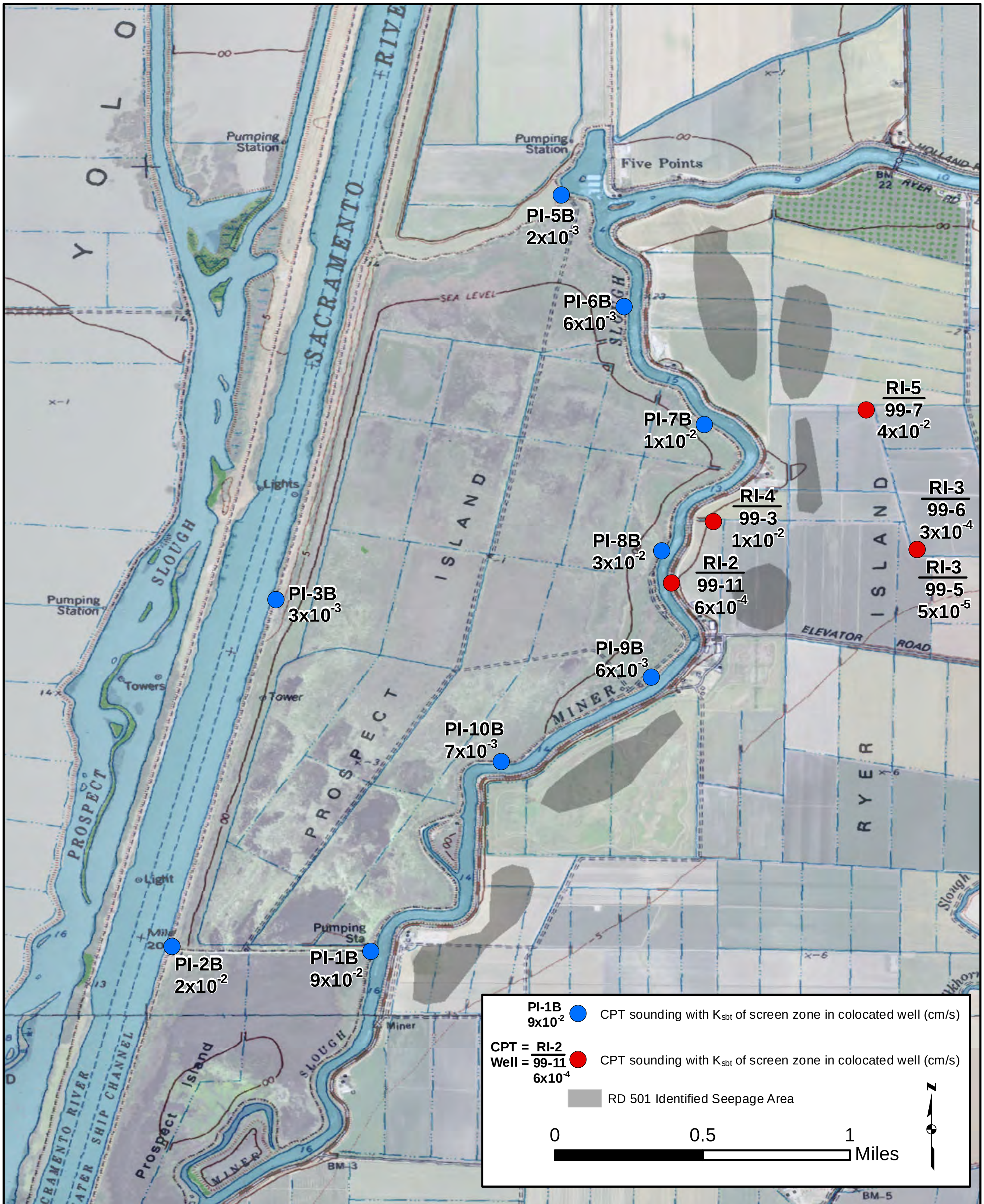
Estimated Hydraulic Conductivity of Main Sand HU Based on K_{sbt} Data

Figure 10-2



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Estimated Hydraulic Conductivity of Main Sand HU Based on K_{sbt} Data Correlated to Adjacent Well - Screen Intervals

Figure 10-3

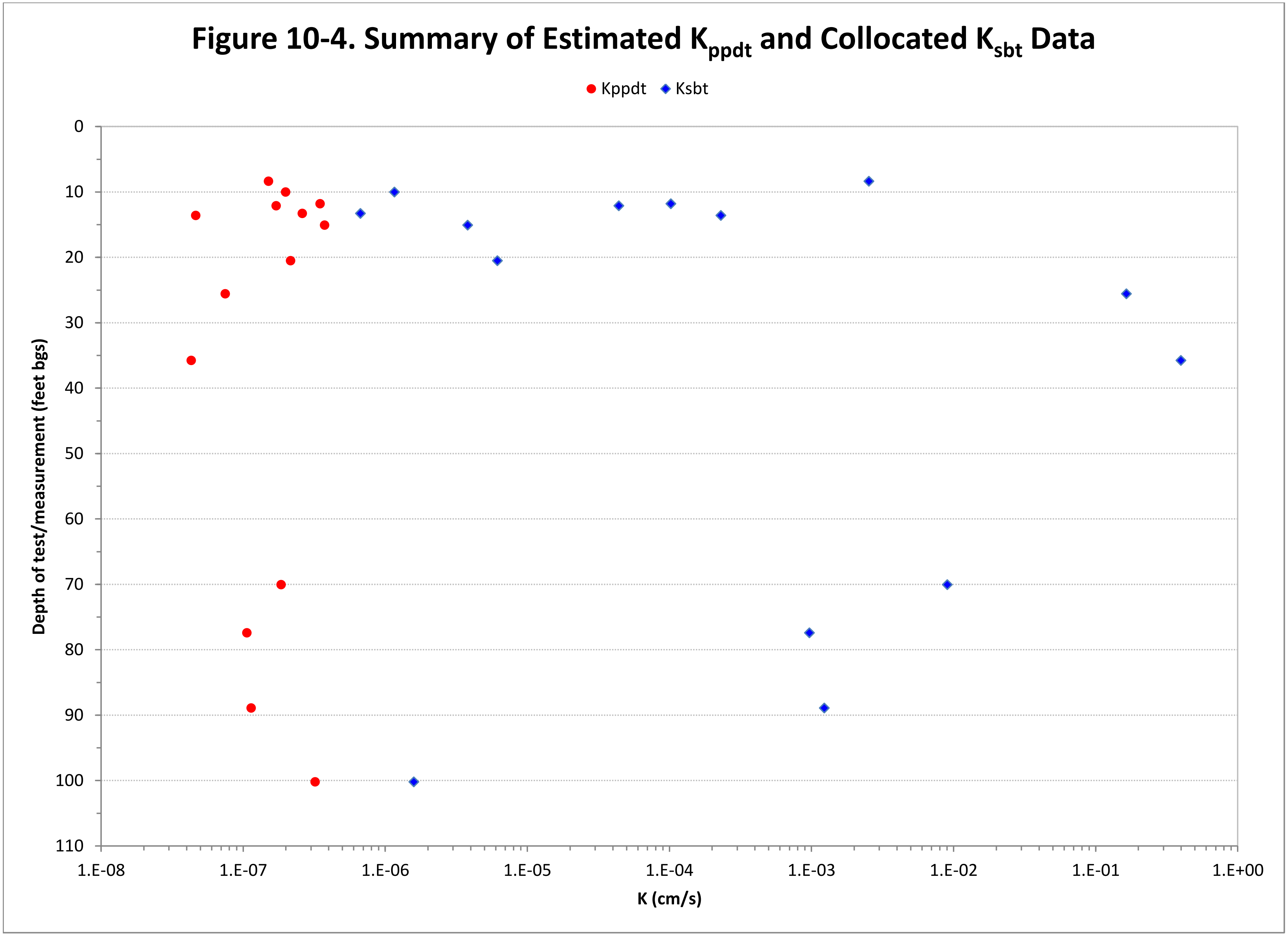
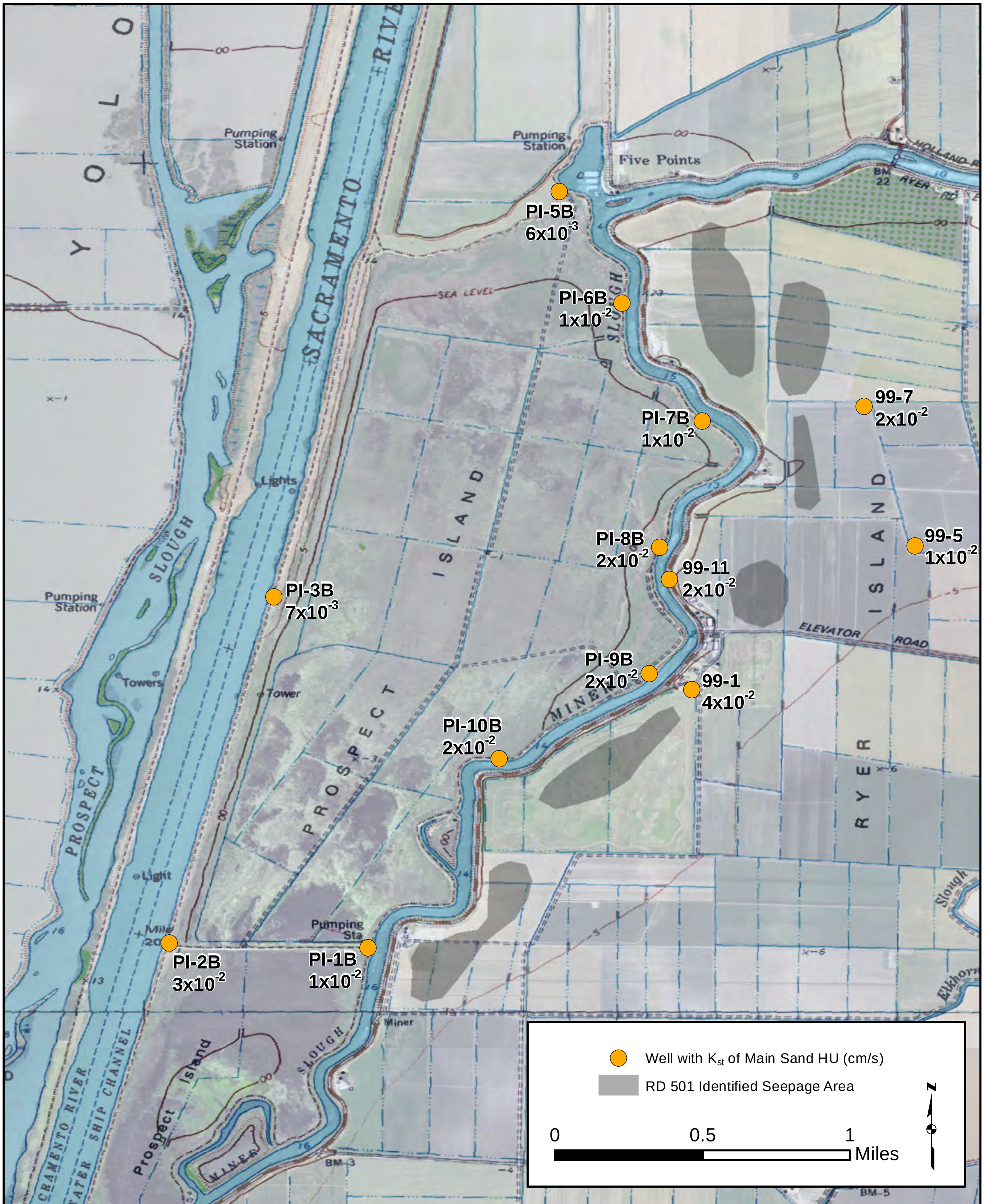


Figure 10-4. Summary of Estimated K_{ppdt} and Collocated K_{sbt} Data
Kppdt
Ksbt
Depth of test/measurement (feet bgs)
0
10
20
30
40
50
60
70
80
90
100
110
1.E-08
1.E-07
1.E-06
1.E-05
1.E-04
1.E-03
1.E-02
1.E-01
1.E+00
K (cm/s)



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Estimated Hydraulic Conductivity of Main Sand HU Based on Slug Testing (K_{st})

Figure 10-5

Figure 10-6. Summary of Hydraulic Conductivity Estimates from Slug Testing (K_{st}) - Main Sand

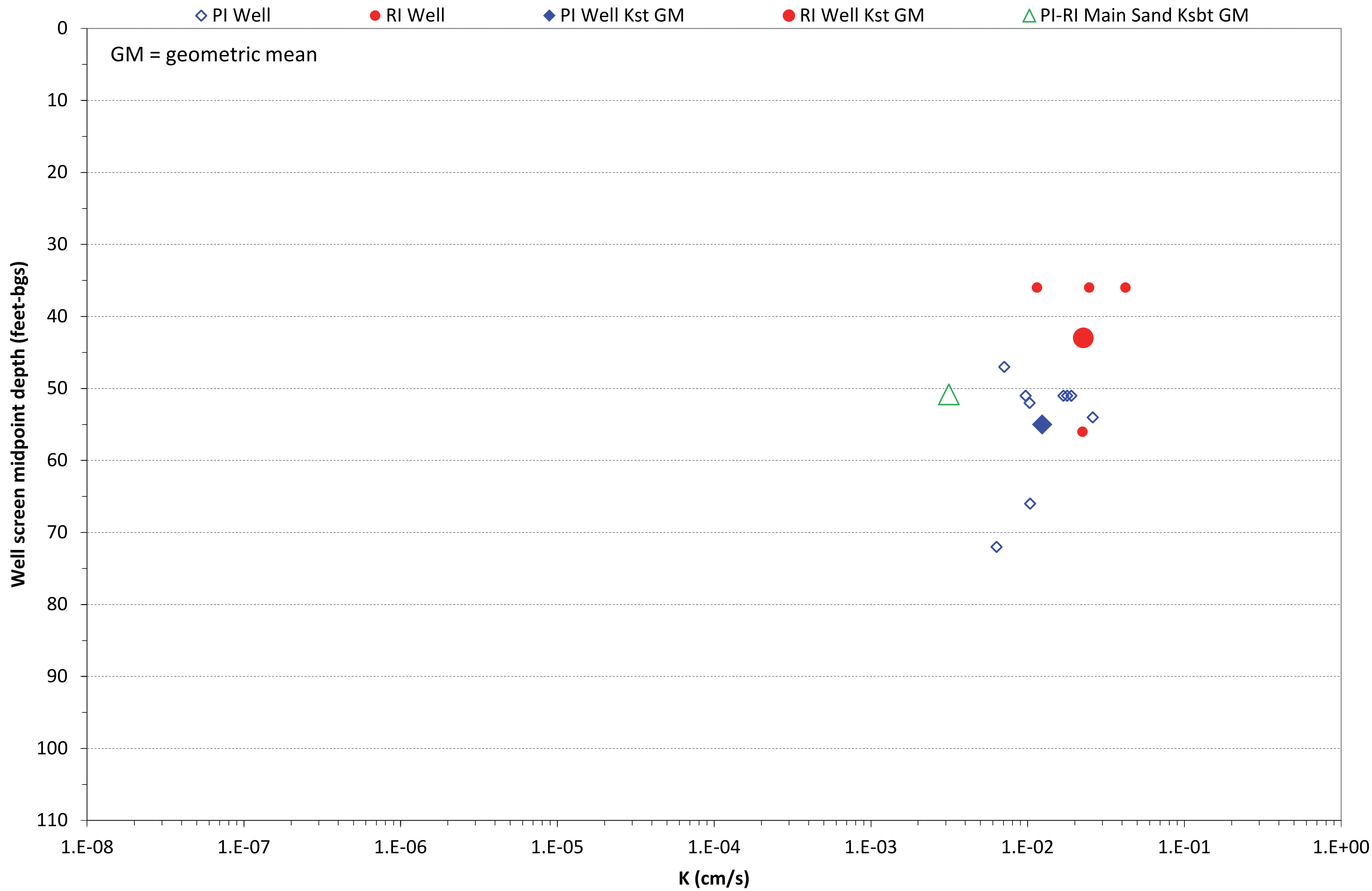


Figure 11-1

Hydrographs of Deep Water Ship Channel and Prospect Island Surface Water Stage, Prospect Island PI-2A and -2B Groundwater Levels with Precipitation at Georgiana Slough

Daily Mean Water Levels, Daily Precipitation - December 21, 2011 to October 1, 2013

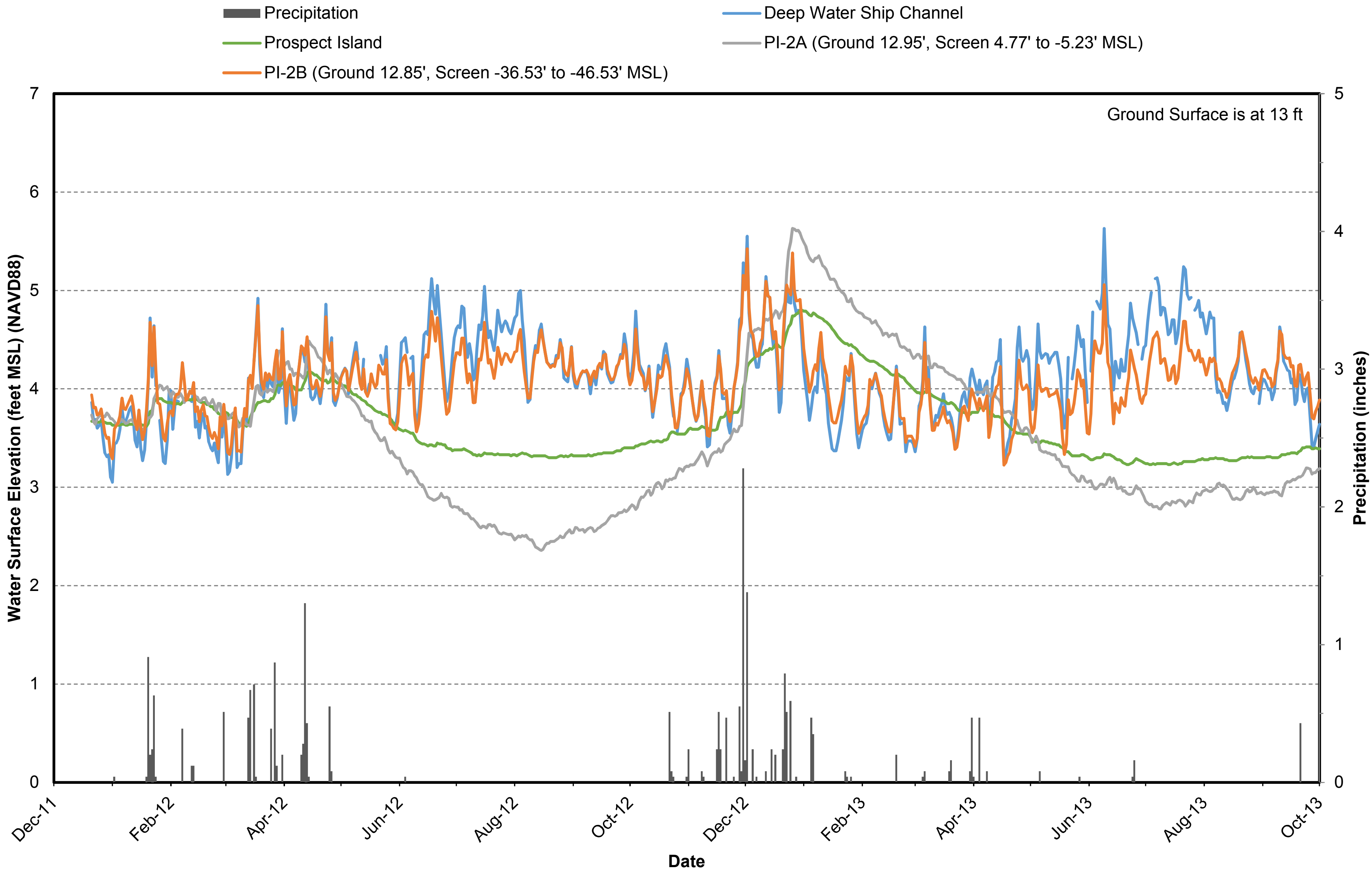


Figure 11-2

Hydrographs of Deep Water Ship Channel and Prospect Island Surface Water Stage, Prospect Island PI-3A, -3B and -3C Groundwater Levels with Precipitation at Georgiana Slough

Daily Mean Water Levels, Daily Precipitation - December 21, 2011 to October 1, 2013

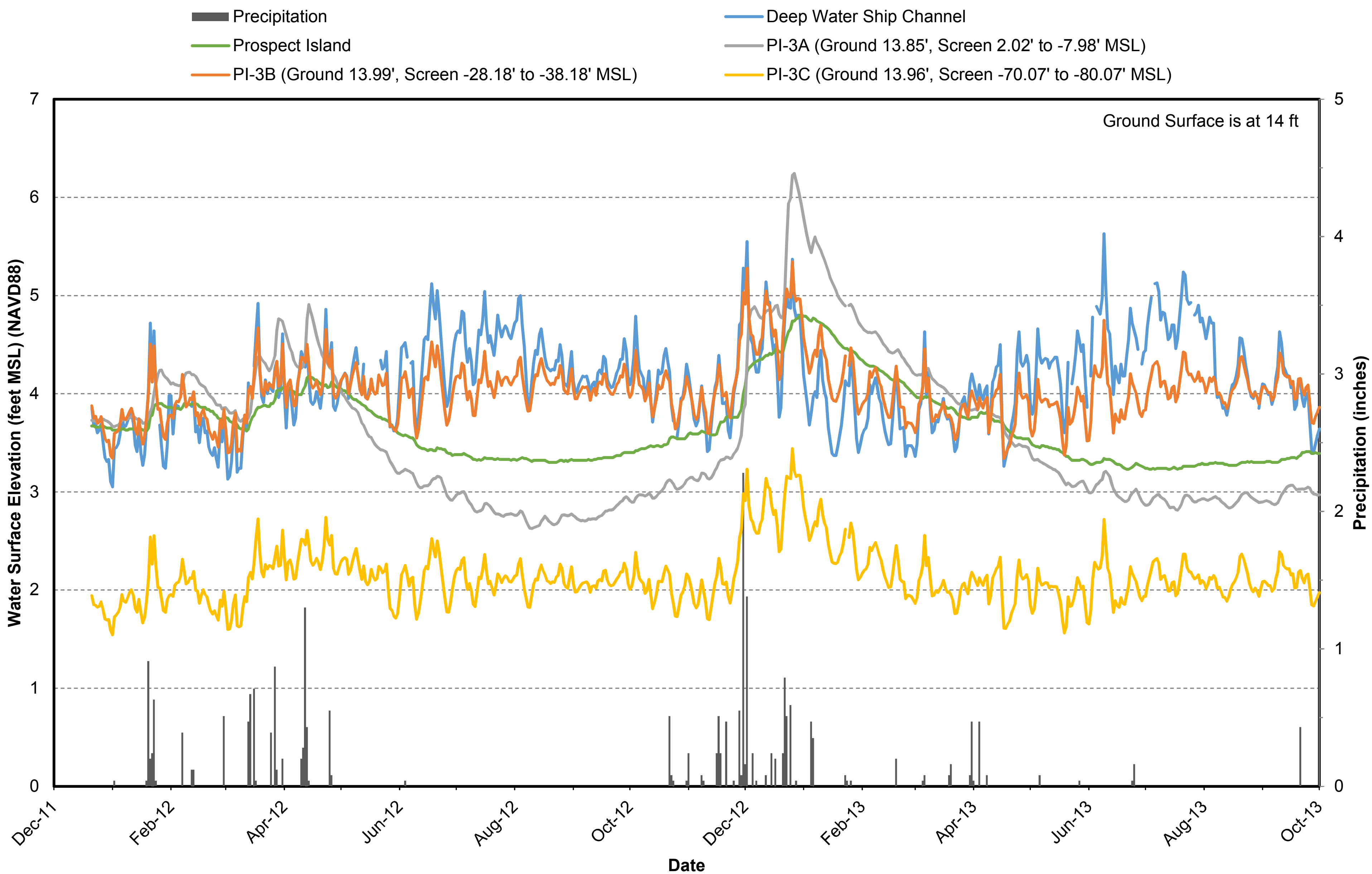


Figure 11-3

Hydrographs of Deep Water Ship Channel, Prospect Island Surface Water Stage and Prospect Island PI-2A and -2B Groundwater Levels with Precipitation at Georgiana Slough

Two Hour Water Levels, Daily Precipitation - August 2012

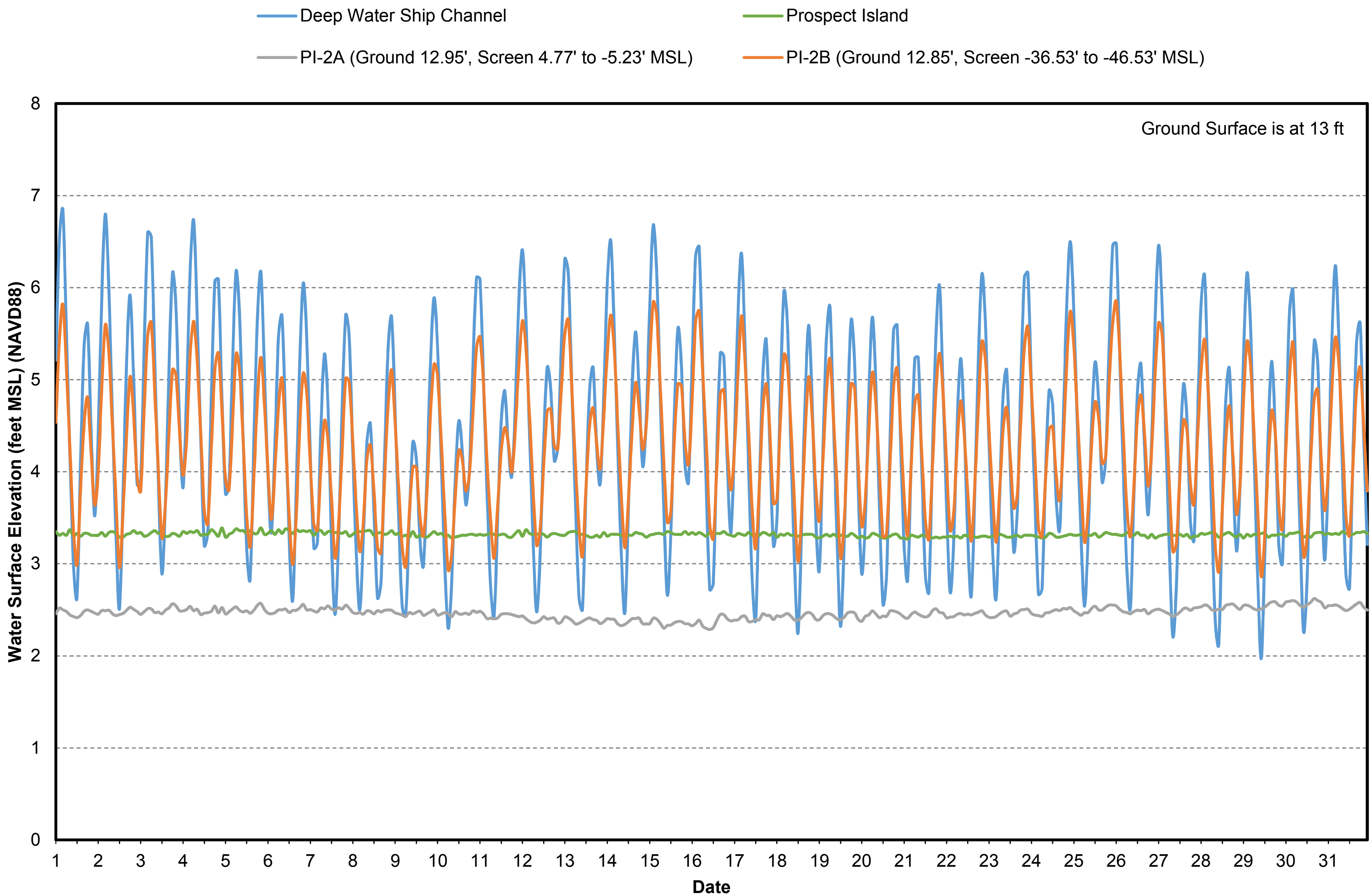


Figure 11-4

Hydrographs of Deep Water Ship Channel, Prospect Island Surface Water Stage and Prospect Island PI-3A, -3B and -3C Groundwater Levels with Precipitation at Georgiana Slough

Two Hour Water Levels, Daily Precipitation - August 2012

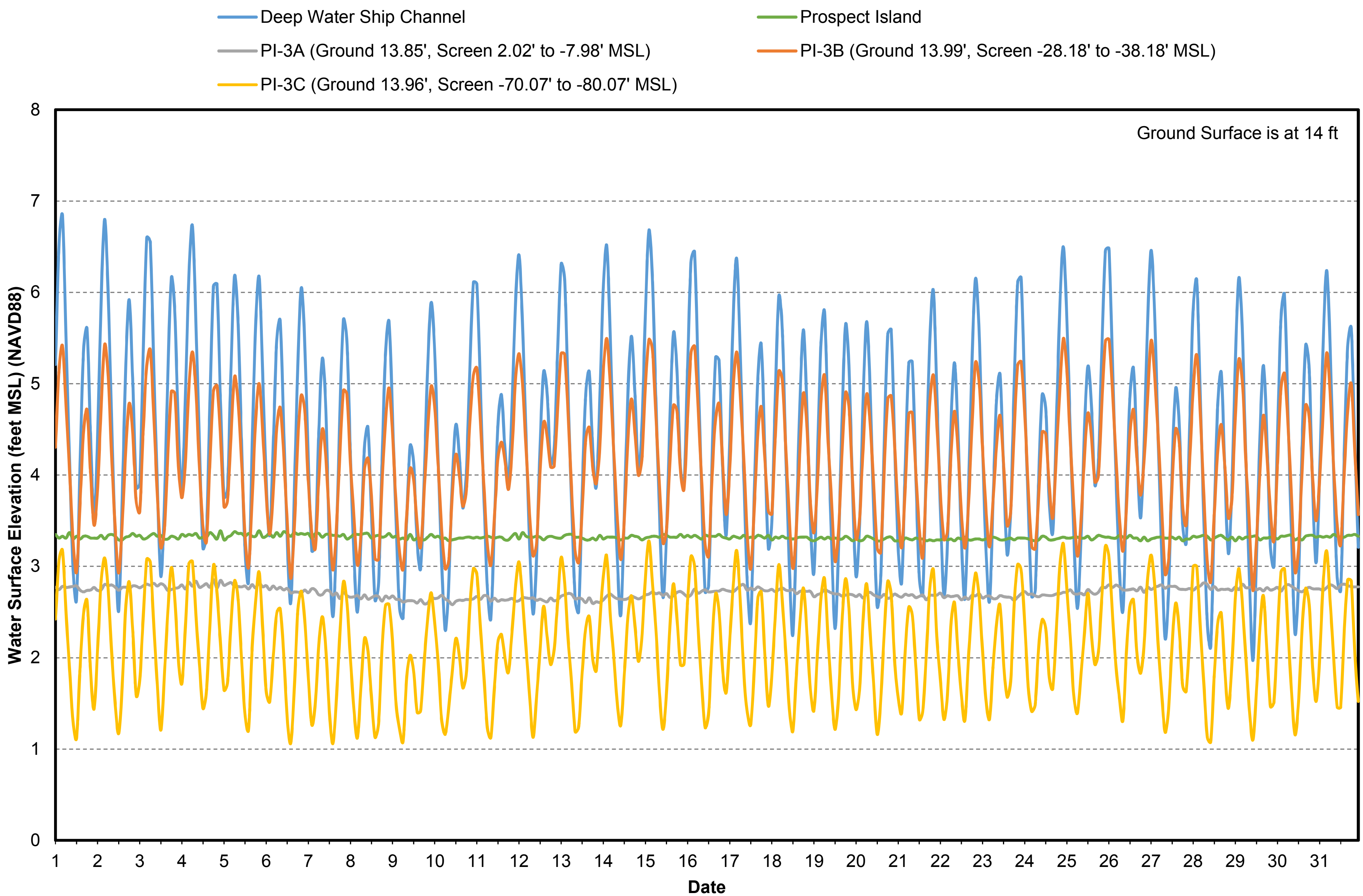


Figure 11-5

Hydrographs of Deep Water Ship Channel, Prospect Island Surface Water Stage and Prospect Island PI-2A and -2B Groundwater Levels with Precipitation at Georgiana Slough

Two Hour Water Levels, Daily Precipitation - December 2012

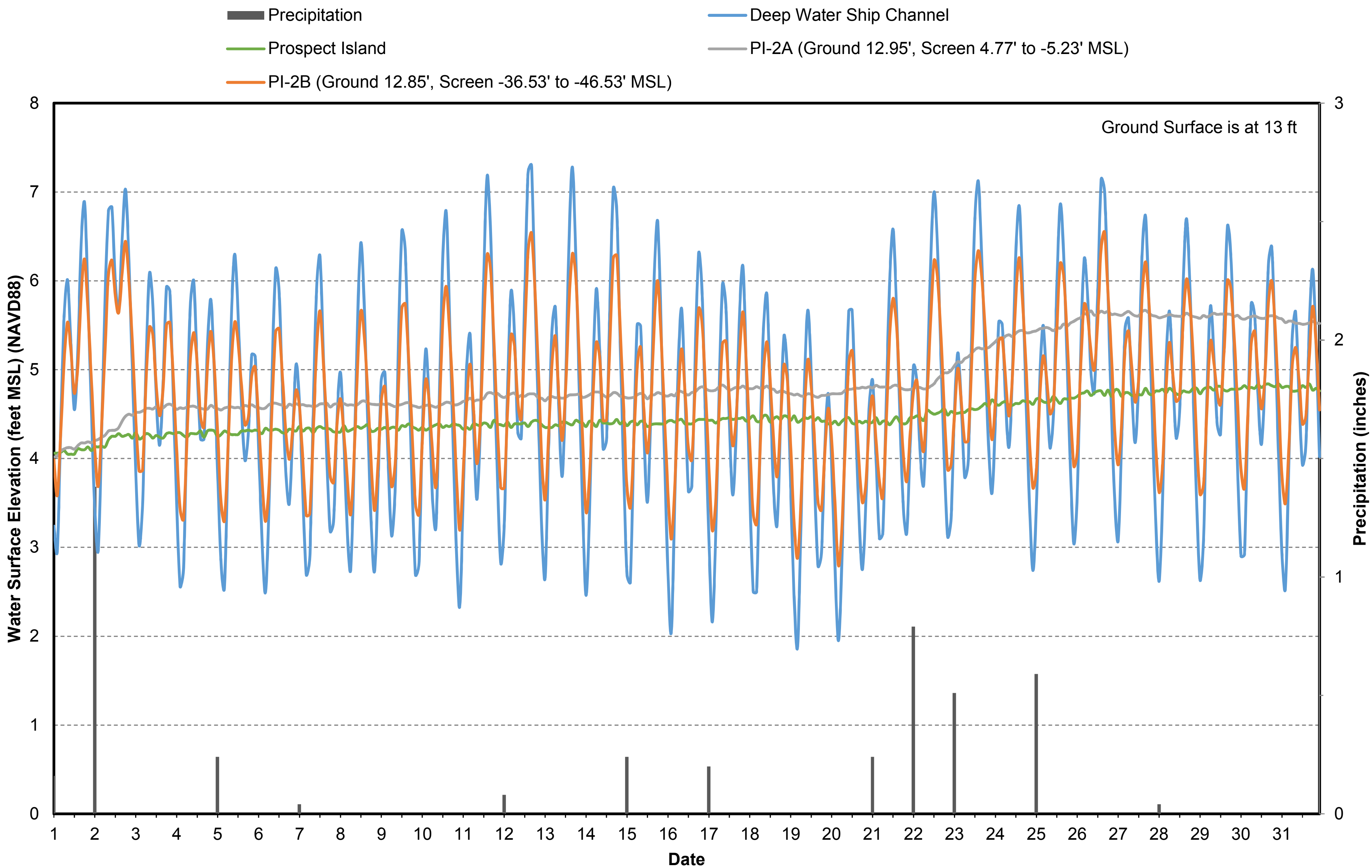


Figure 11-6

Hydrographs of Deep Water Ship Channel, Prospect Island Surface Water Stage and Prospect Island PI-3A, -3B and -3C Groundwater Levels with Precipitation at Georgiana Slough

Two Hour Water Levels, Daily Precipitation - December 2012

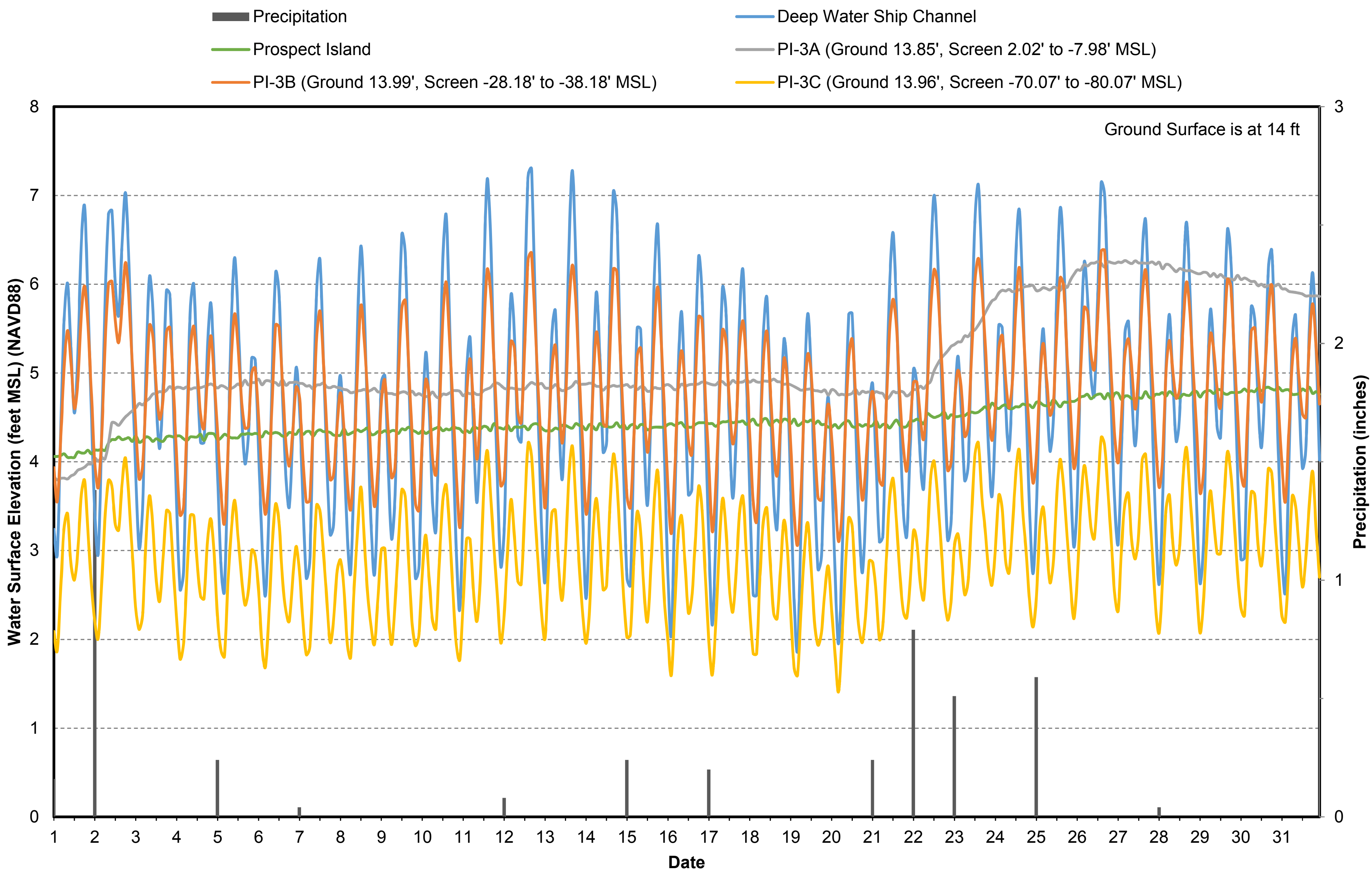


Figure 11-7

Hydrographs of Miner Slough and Prospect Island Surface Water Stage, Prospect Island PI-5A and -5B Groundwater Levels with Precipitation at Georgiana Slough

Daily Mean Water Levels, Daily Precipitation - December 21, 2011 to October 1, 2013

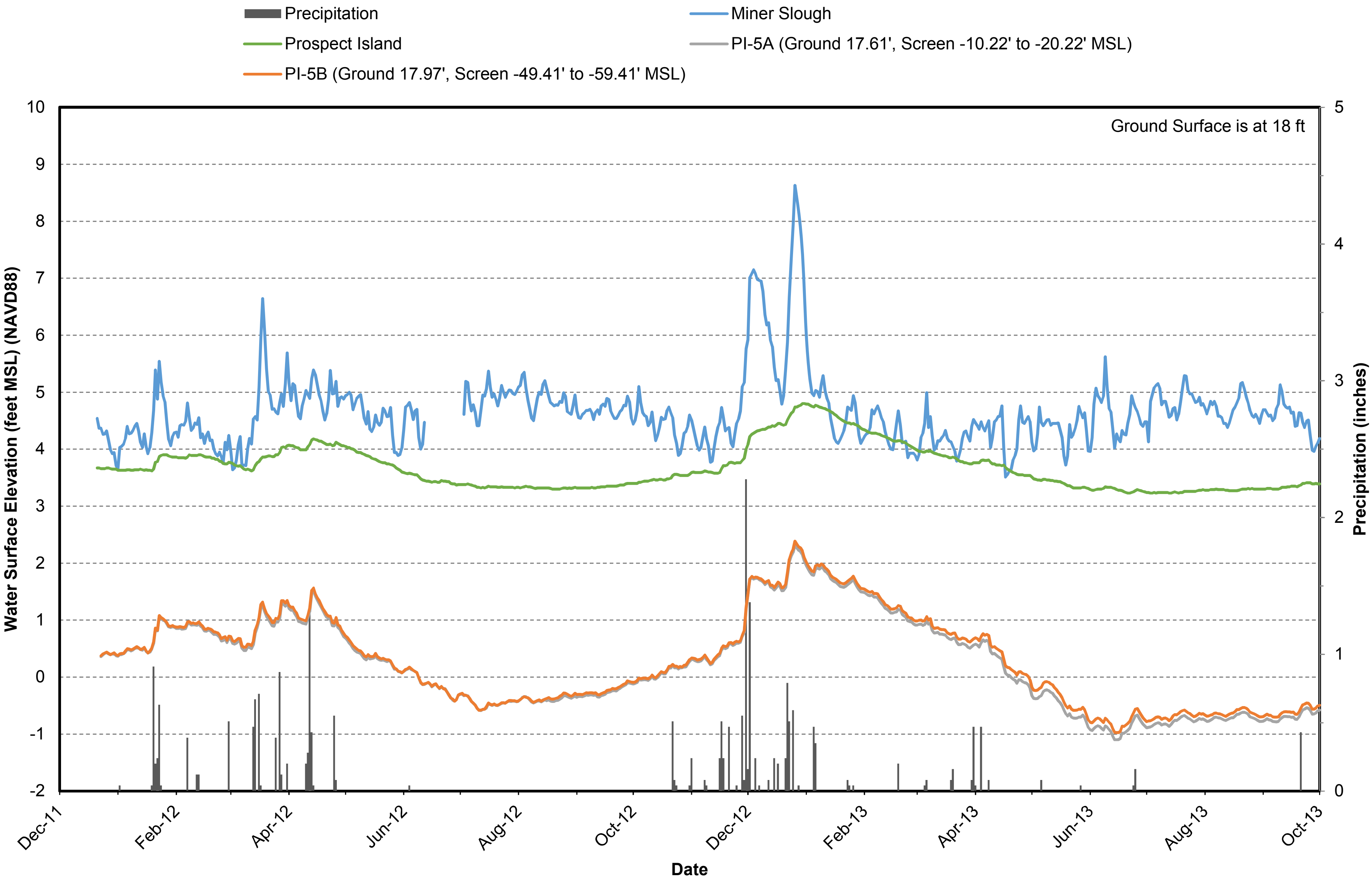


Figure 11-8

Hydrographs of Miner Slough, Prospect Island Surface Water Stage and Prospect Island PI-5A and -5B Groundwater Levels

Two Hour Water Levels - August 2012

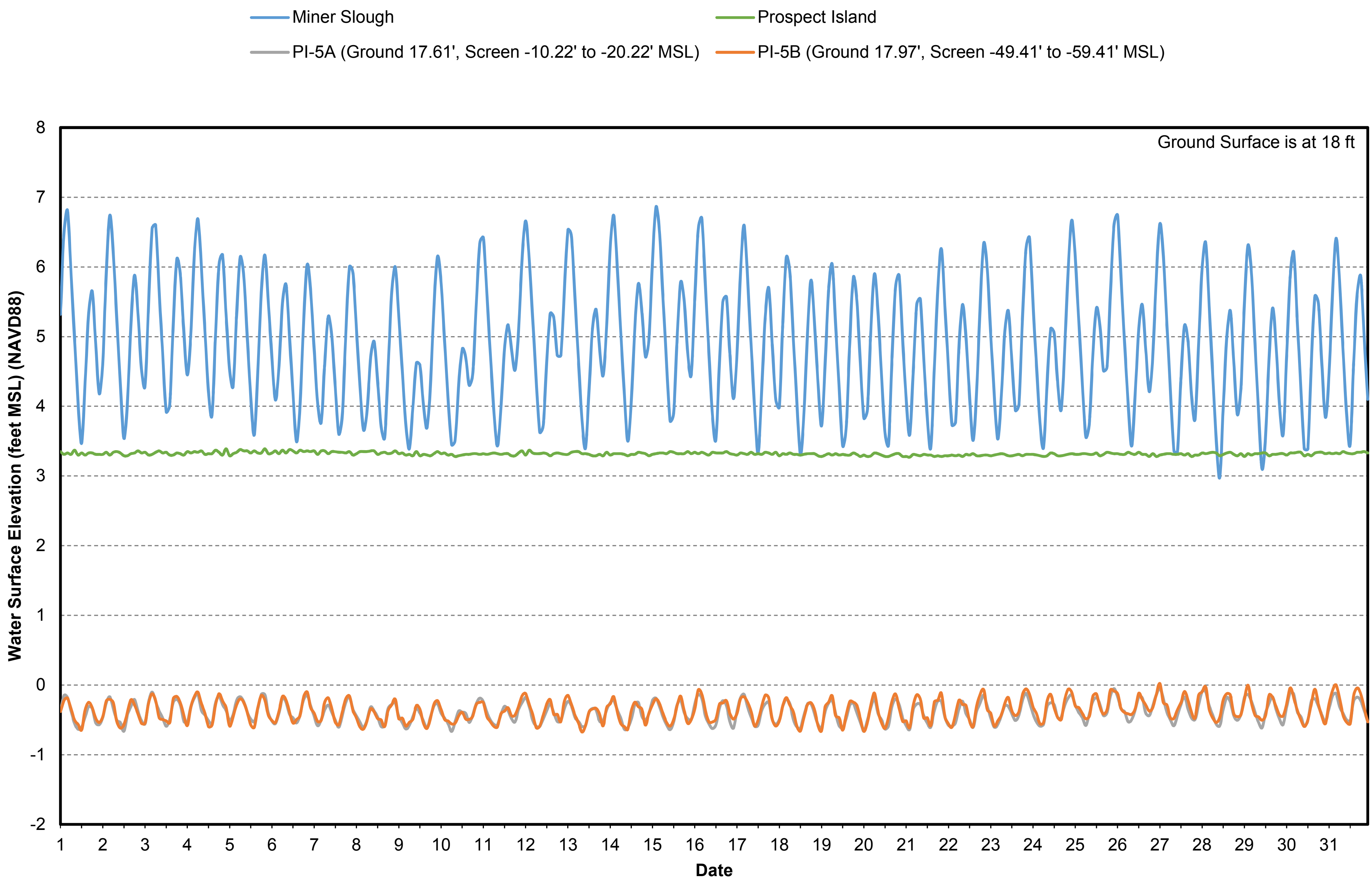
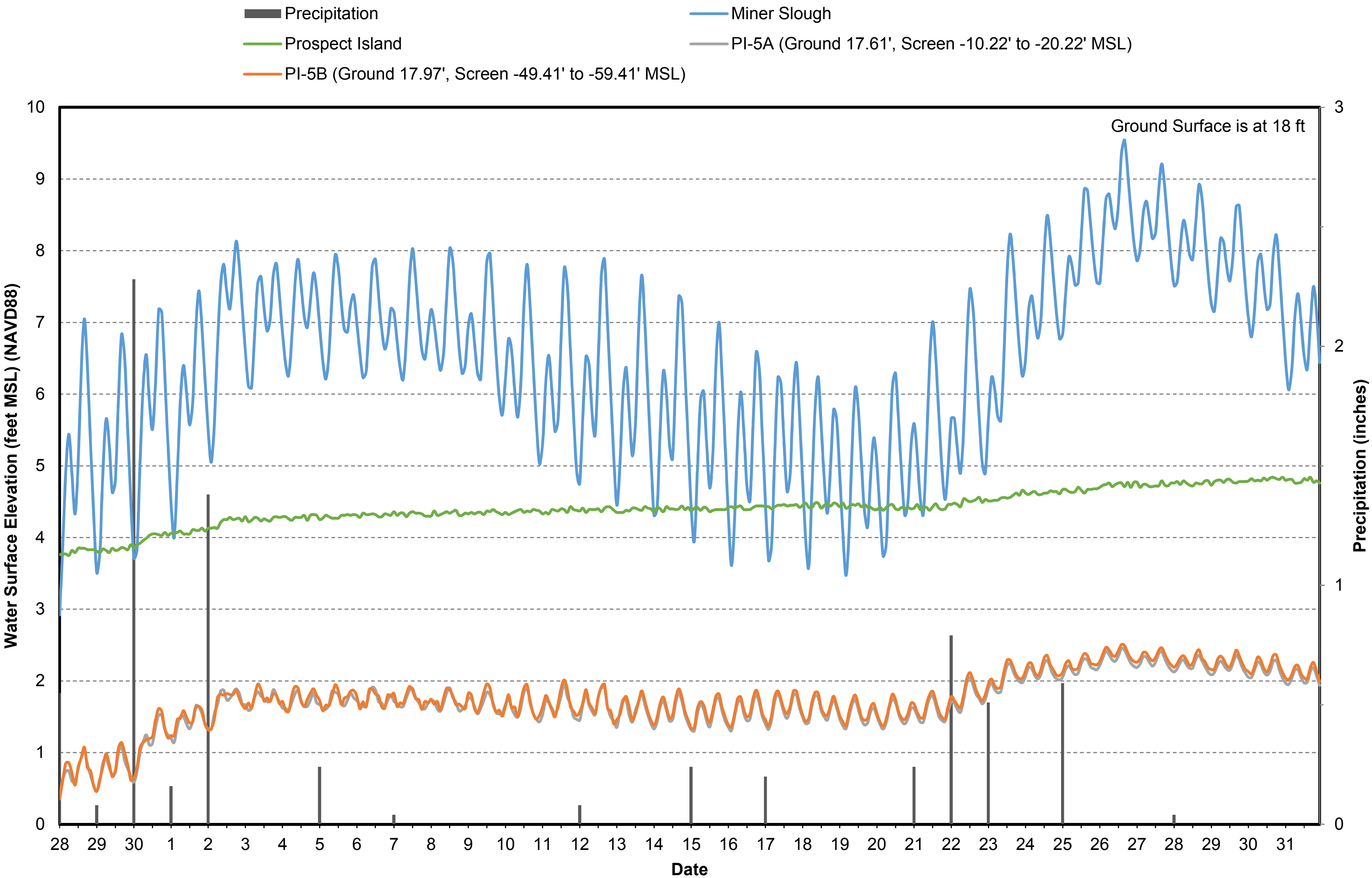


Figure 11-9

Hydrographs of Miner Slough, Prospect Island Surface Water Stage and Prospect Island PI-5A and -5B Groundwater Levels with Precipitation at Georgiana Slough

Two Hour Water Levels, Daily Precipitation - November 28 through December 31, 2012



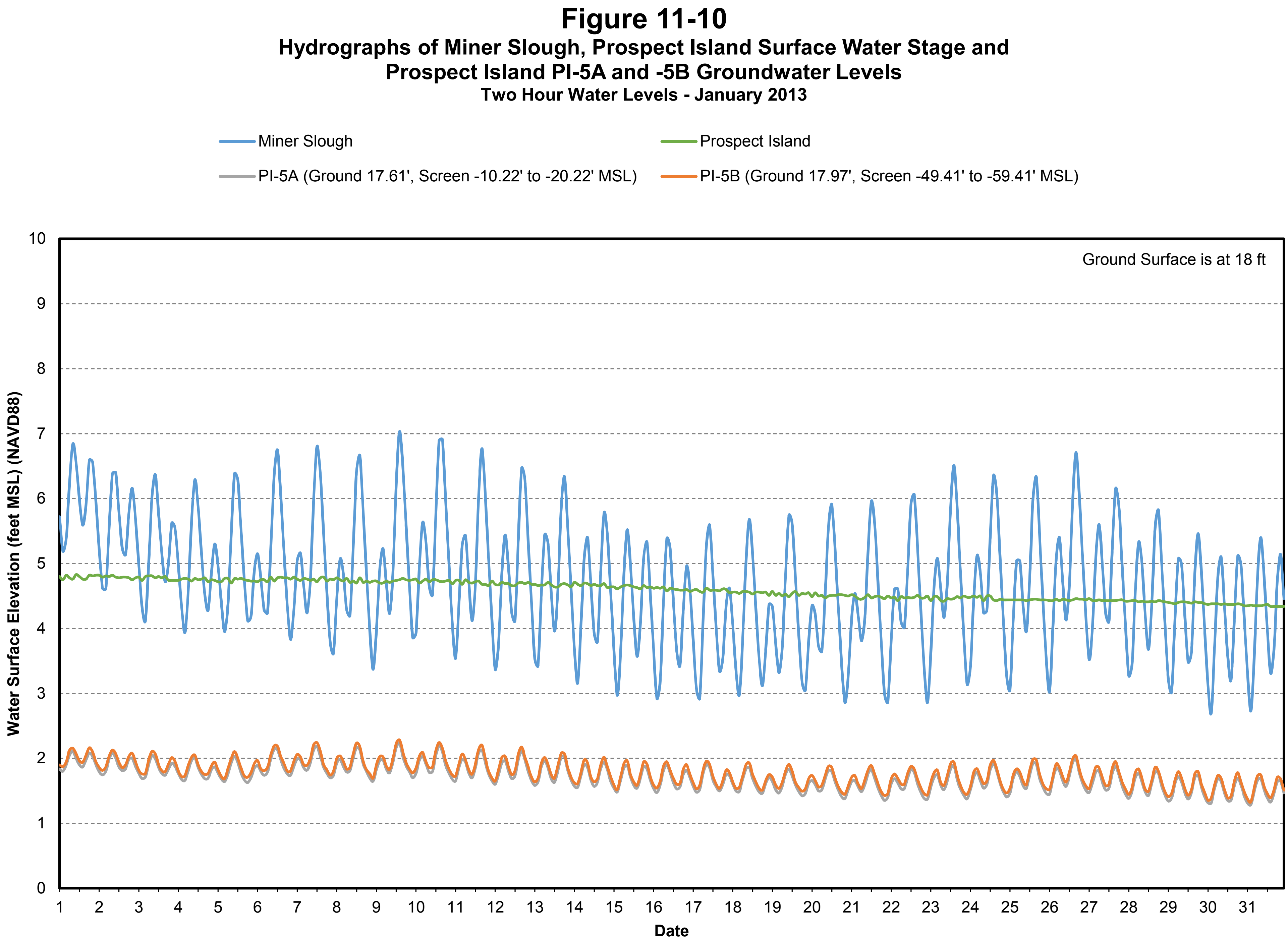


Figure 11-10
Hydrographs of Miner Slough, Prospect Island Surface Water Stage and
Prospect Island PI-5A and -5B Groundwater Levels
Two Hour Water Levels - January 2013
Miner Slough
Prospect Island
PI-5A (Ground 17.61', Screen -10.22' to -20.22' MSL)
PI-5B (Ground 17.97', Screen -49.41' to -59.41' MSL)
Ground Surface is at 18 ft
Water Surface Elevation (feet MSL) (NAVD88)
Date
0
1
2
3
4
5
6
7
8
9
10
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31

Figure 11-11

Hydrographs of Miner Slough and Prospect Island Surface Water Stage, Prospect Island PI-6A and -6B Groundwater Levels with Precipitation at Georgiana Slough

Daily Mean Water Levels, Daily Precipitation - December 21, 2011 to October 1, 2013

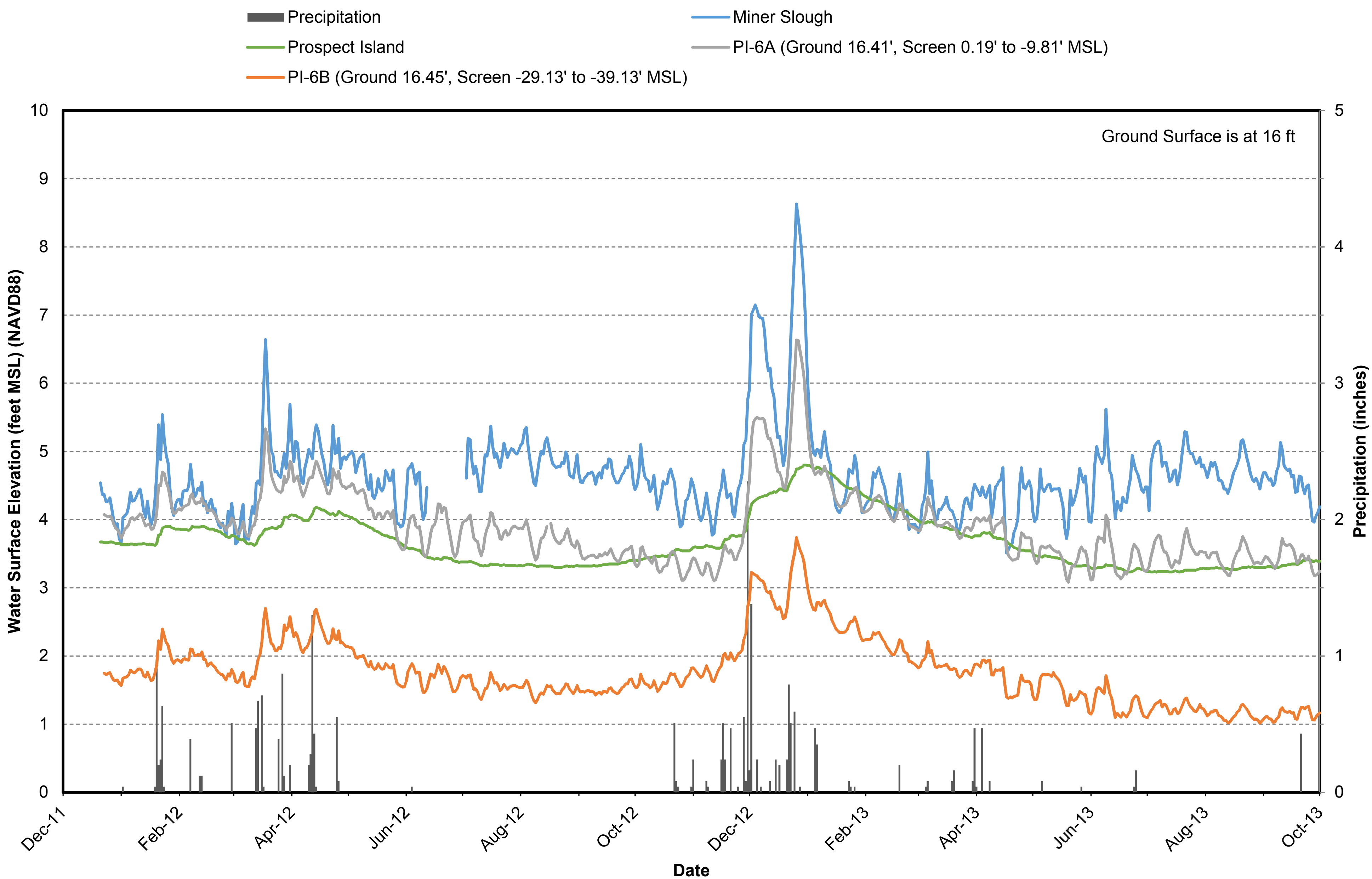


Figure 11-12

Hydrographs of Miner Slough and Prospect Island Surface Water Stage, Prospect Island PI-7A and -7B Groundwater Levels with Precipitation at Georgiana Slough

Daily Mean Water Levels, Daily Precipitation - December 21, 2011 to October 1, 2013

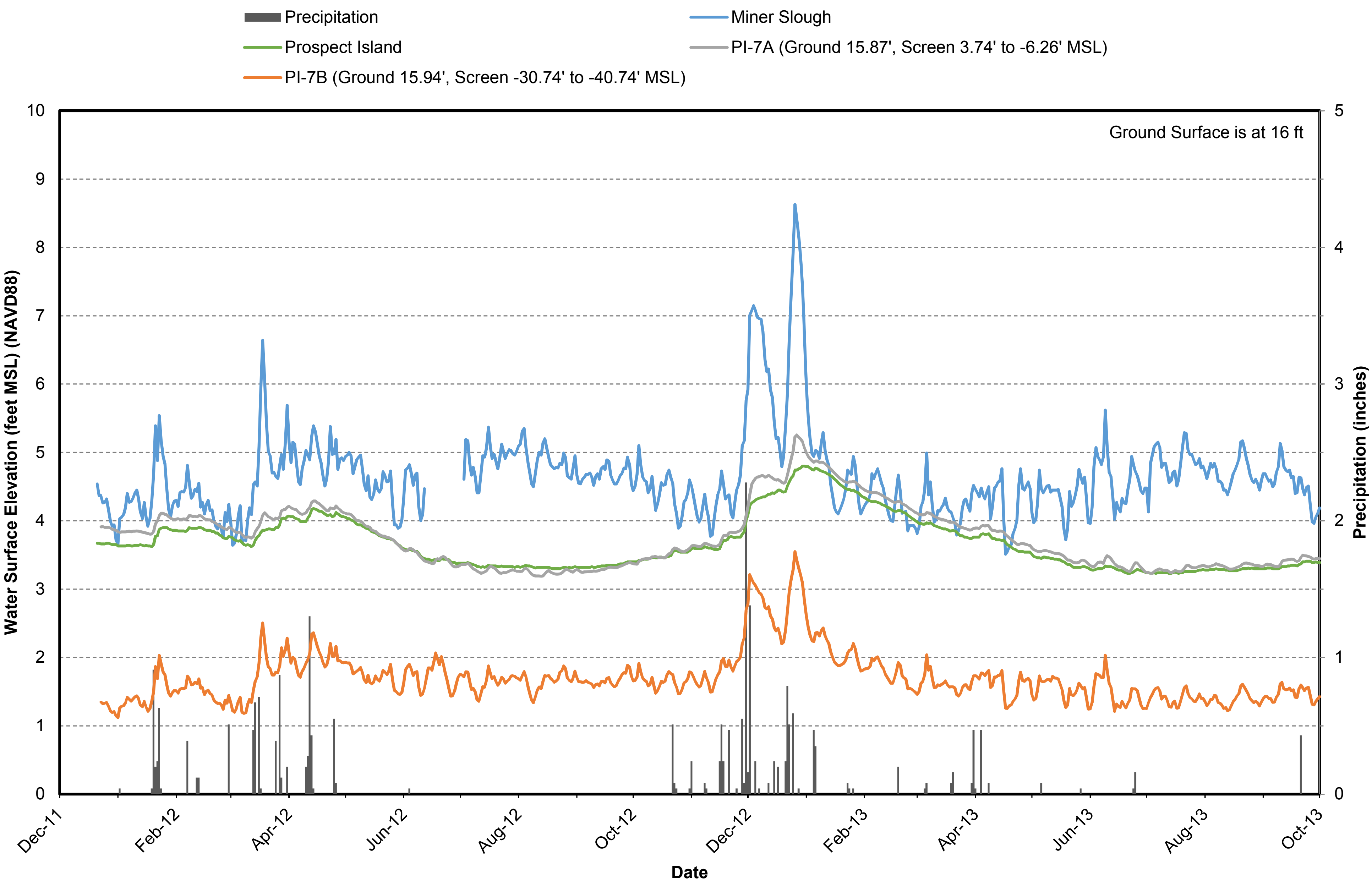


Figure 11-13

Hydrographs of Miner Slough and Prospect Island Surface Water Stage, Prospect Island PI-8A and -8B Groundwater Levels with Precipitation at Georgiana Slough

Daily Mean Water Levels, Daily Precipitation - December 21, 2011 to October 1, 2013

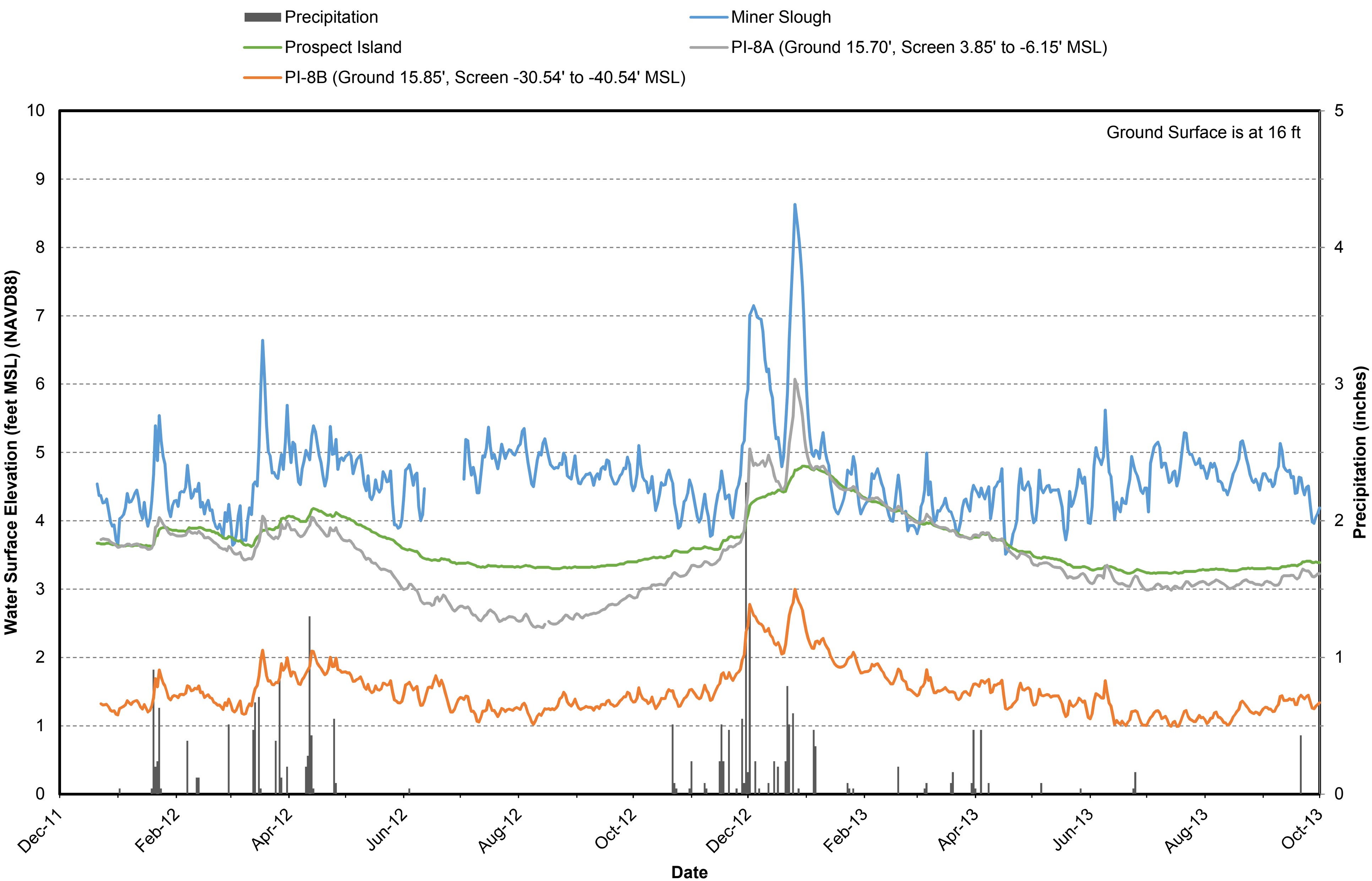


Figure 11-14

Hydrographs of Miner Slough and Prospect Island Surface Water Stage, Prospect Island PI-9A, -9B and -9C Groundwater Levels with Precipitation at Georgiana Slough

Daily Mean Water Levels, Daily Precipitation - December 21, 2011 to October 1, 2013

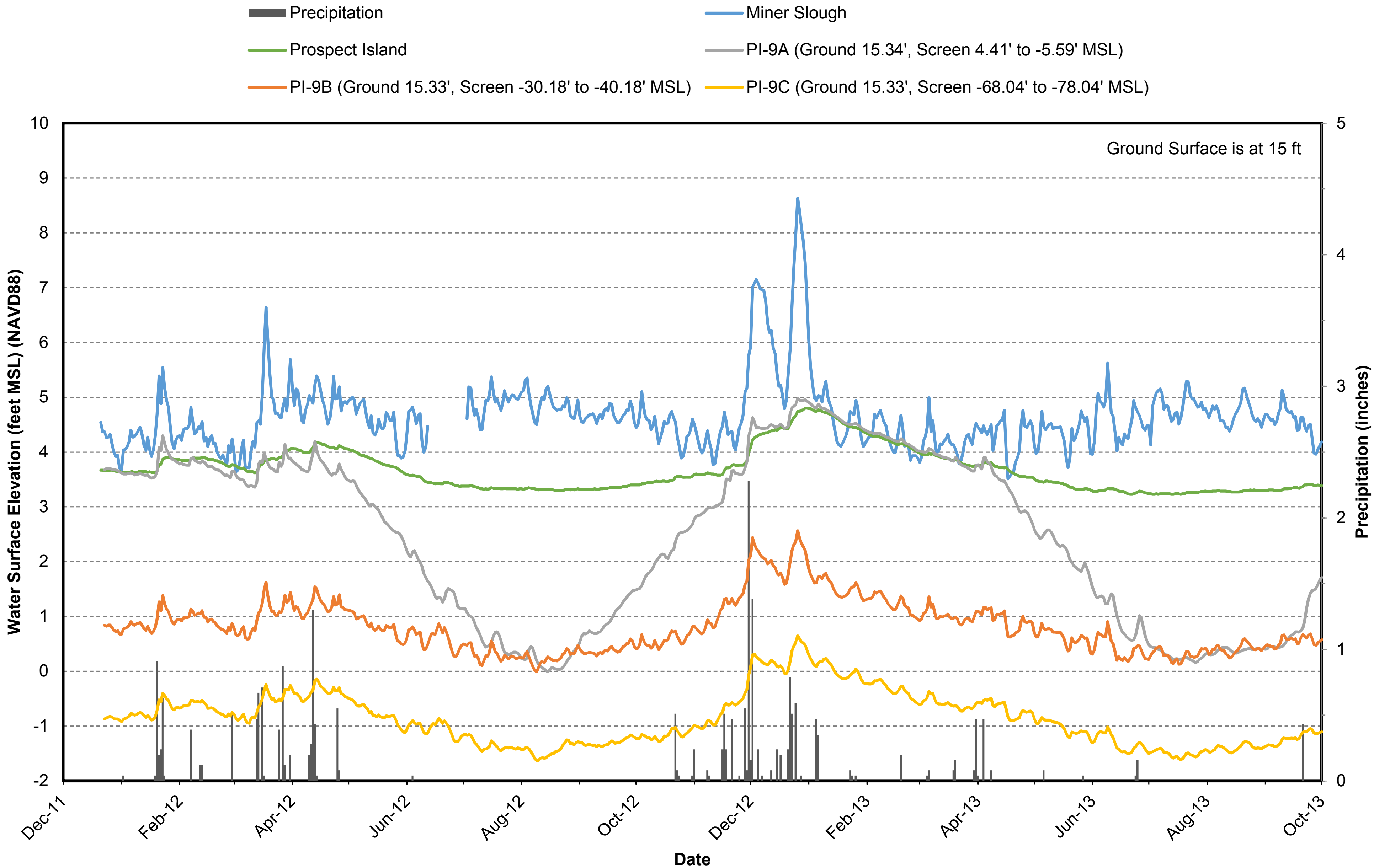


Figure 11-15

Hydrographs of Miner Slough and Prospect Island Surface Water Stage, Prospect Island PI-10A and -10B Groundwater Levels with Precipitation at Georgiana Slough

Daily Mean Water Levels, Daily Precipitation - December 21, 2011 to October 1, 2013

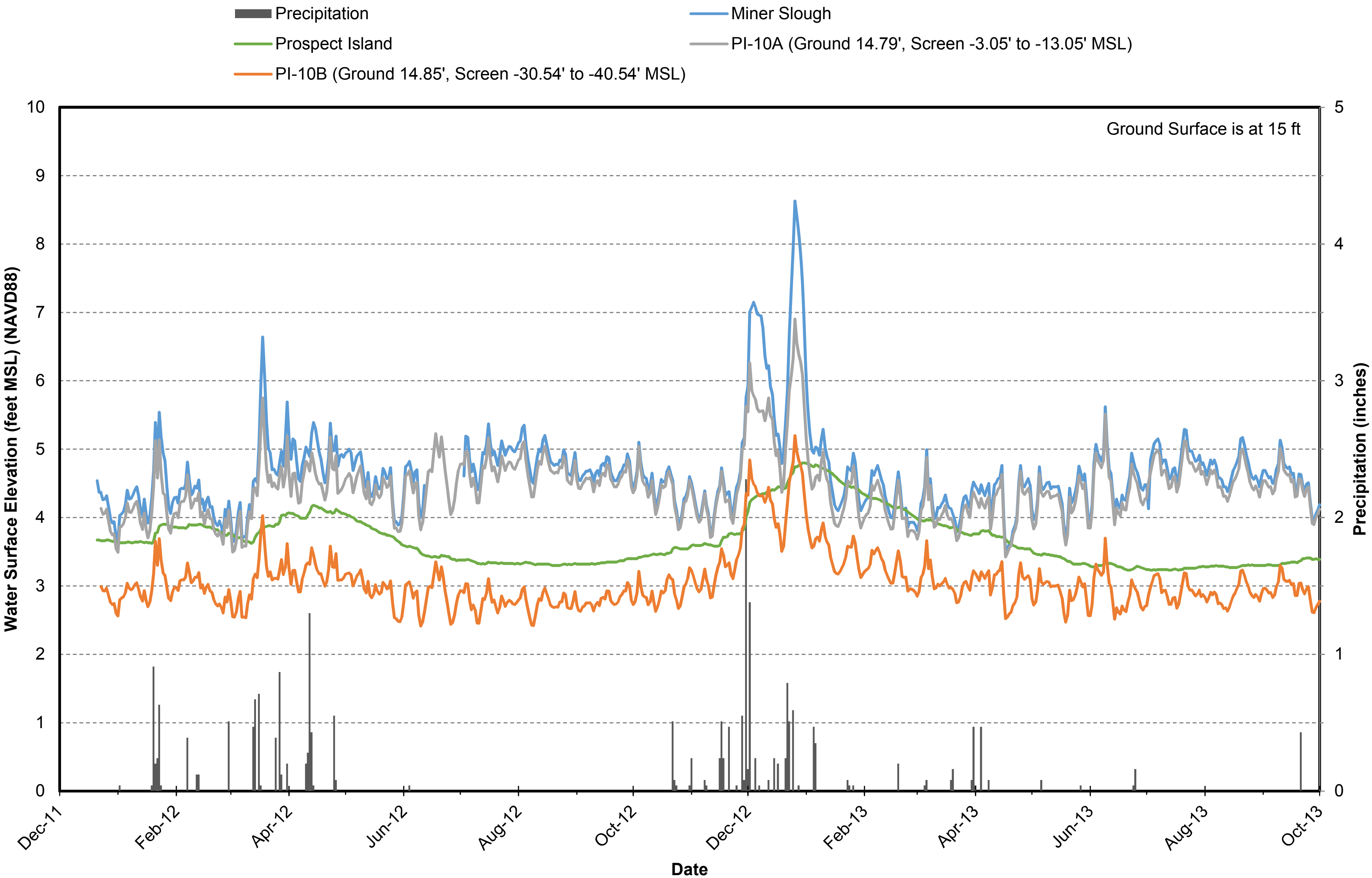


Figure 11-16

**Hydrographs of Miner Slough and Prospect Island Surface Water Stage,
Prospect Island PI-1A and -1B Groundwater Levels with Precipitation at Georgiana Slough**

Daily Mean Water Levels, Daily Precipitation - December 21, 2011 to October 1, 2013

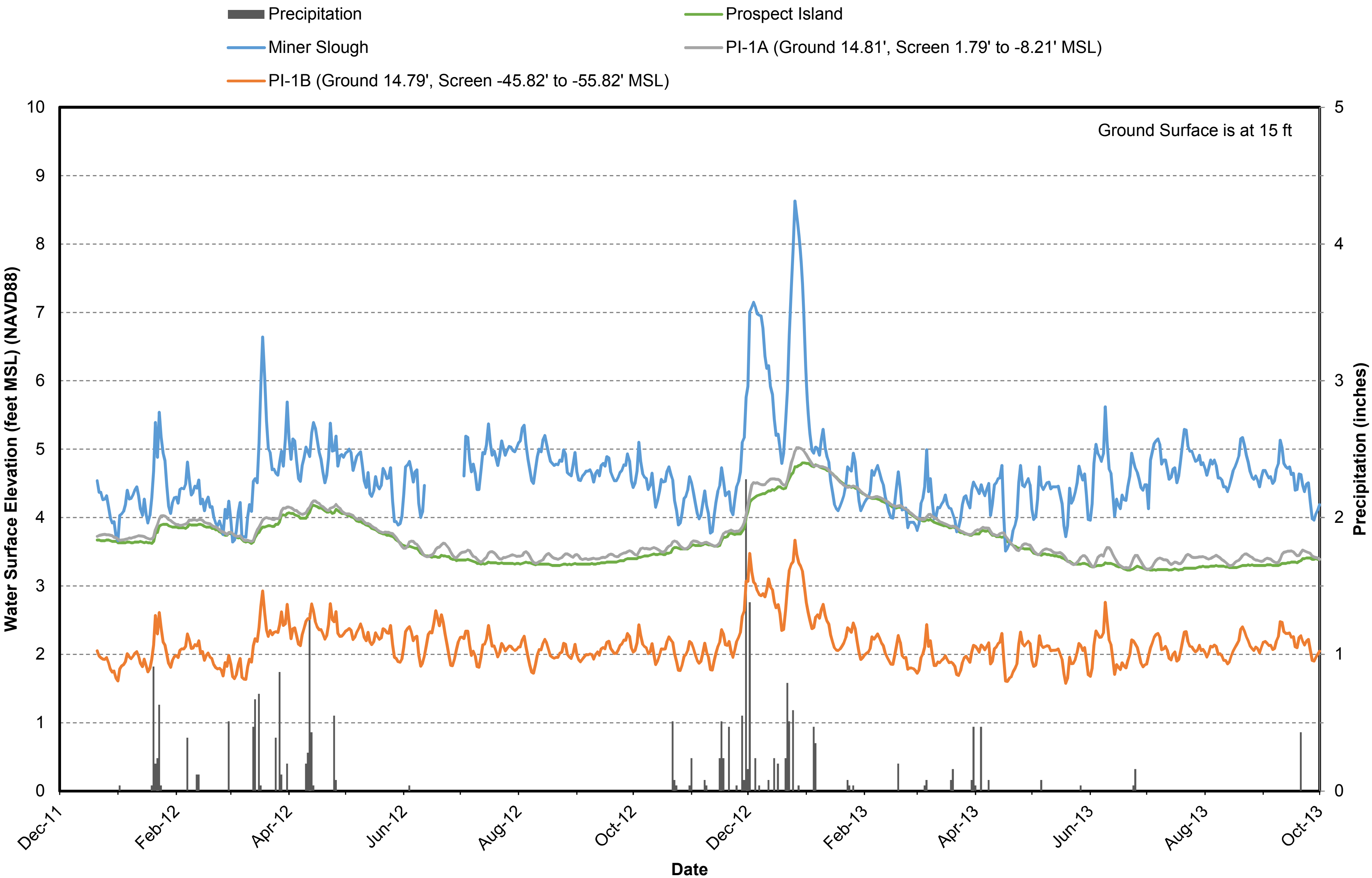


Figure 11-17

Hydrographs of Miner Slough, Prospect Island Surface Water Stage and Prospect Island PI-6A and -6B Groundwater Levels

Two Hour Water Levels - August 2012

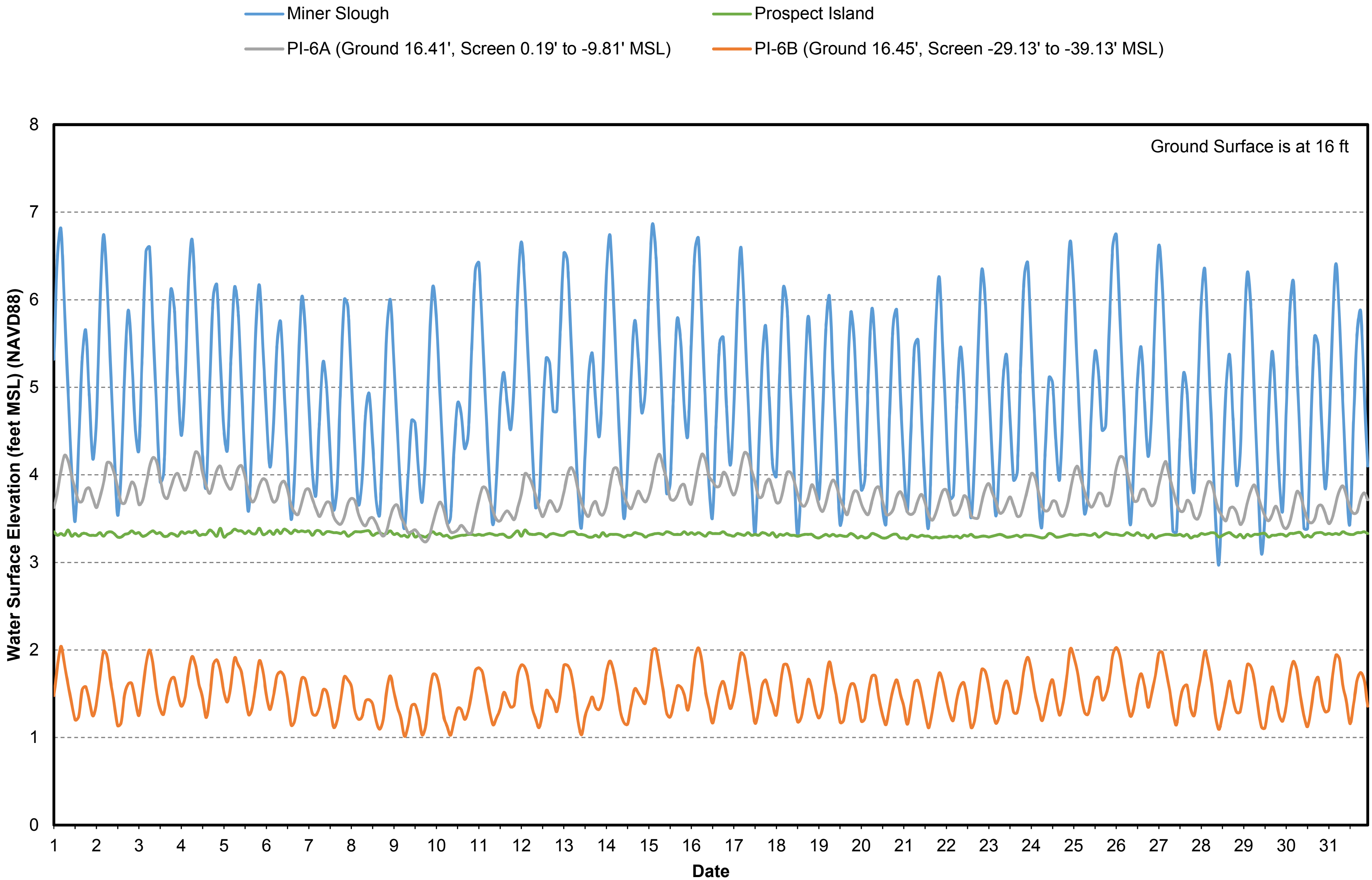


Figure 11-18

Hydrographs of Miner Slough, Prospect Island Surface Water Stage and Prospect Island PI-7A and -7B Groundwater Levels

Two Hour Water Levels - August 2012

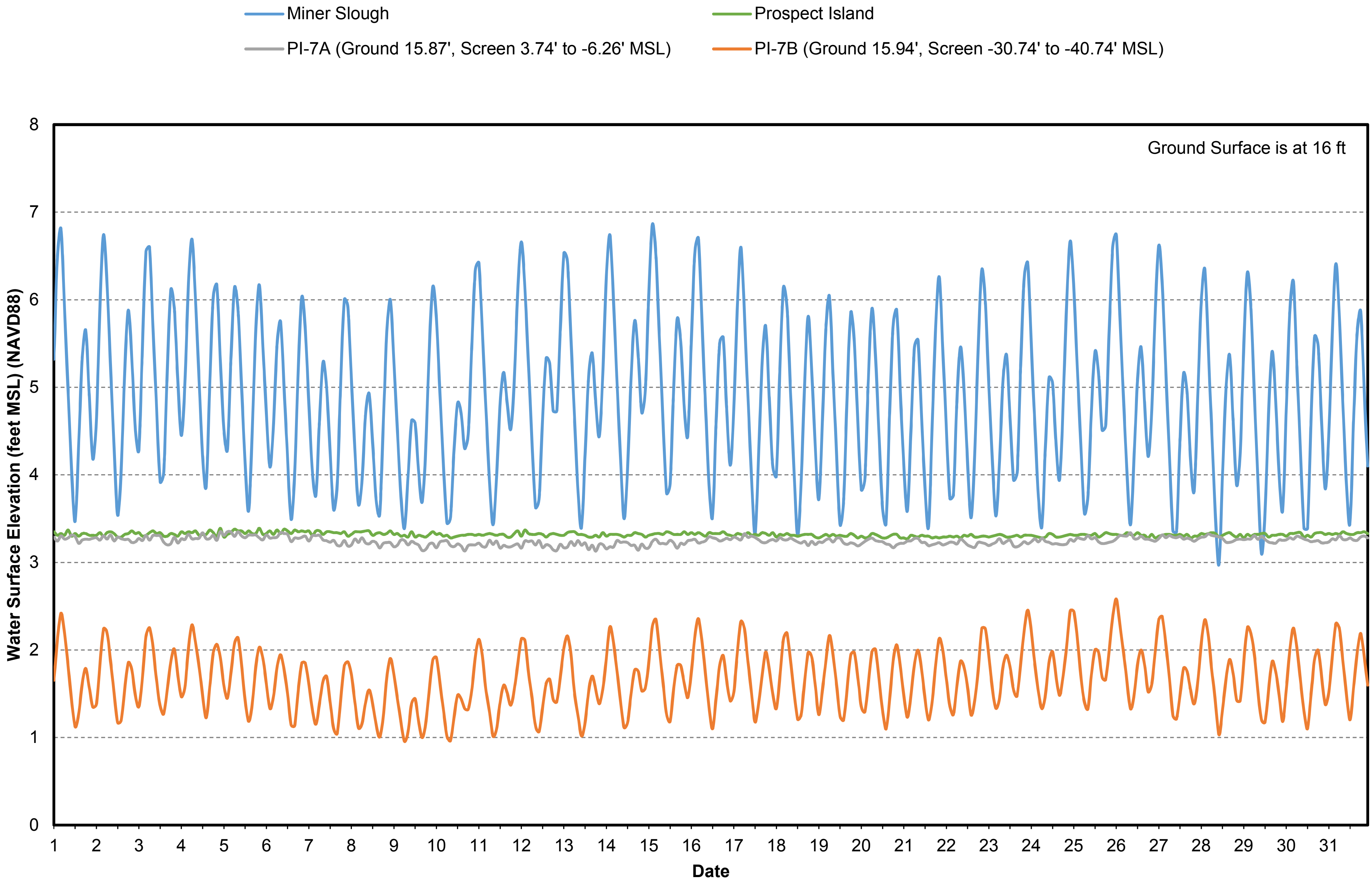


Figure 11-19
Hydrographs of Miner Slough, Prospect Island Surface Water Stage and Prospect Island PI-8A and -8B Groundwater Levels
Two Hour Water Levels - August 2012

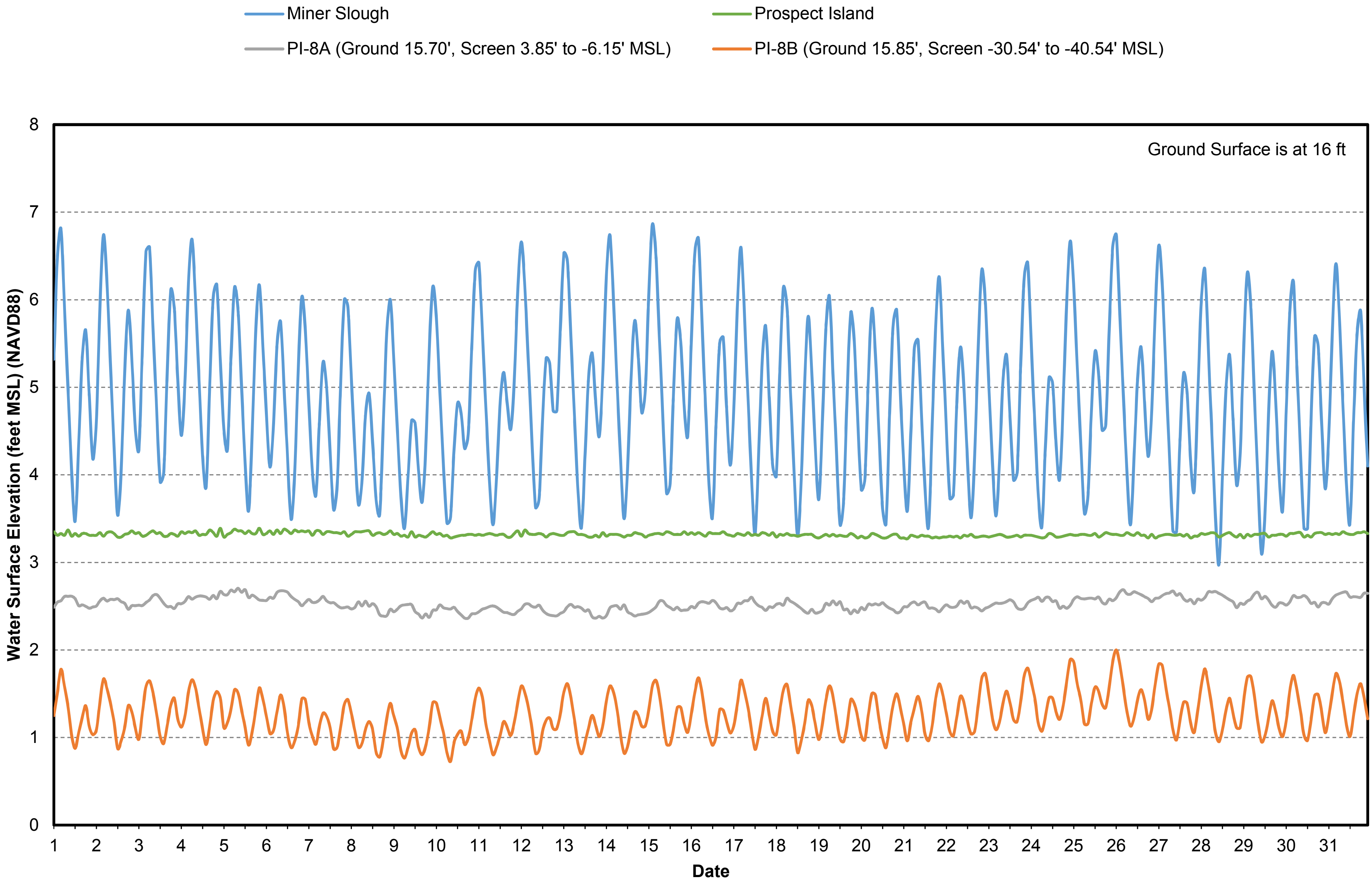


Figure 11-20

Hydrographs of Miner Slough, Prospect Island Surface Water Stage and Prospect Island PI-9A, -9B and -9C Groundwater Levels

Two Hour Water Levels - August 2012

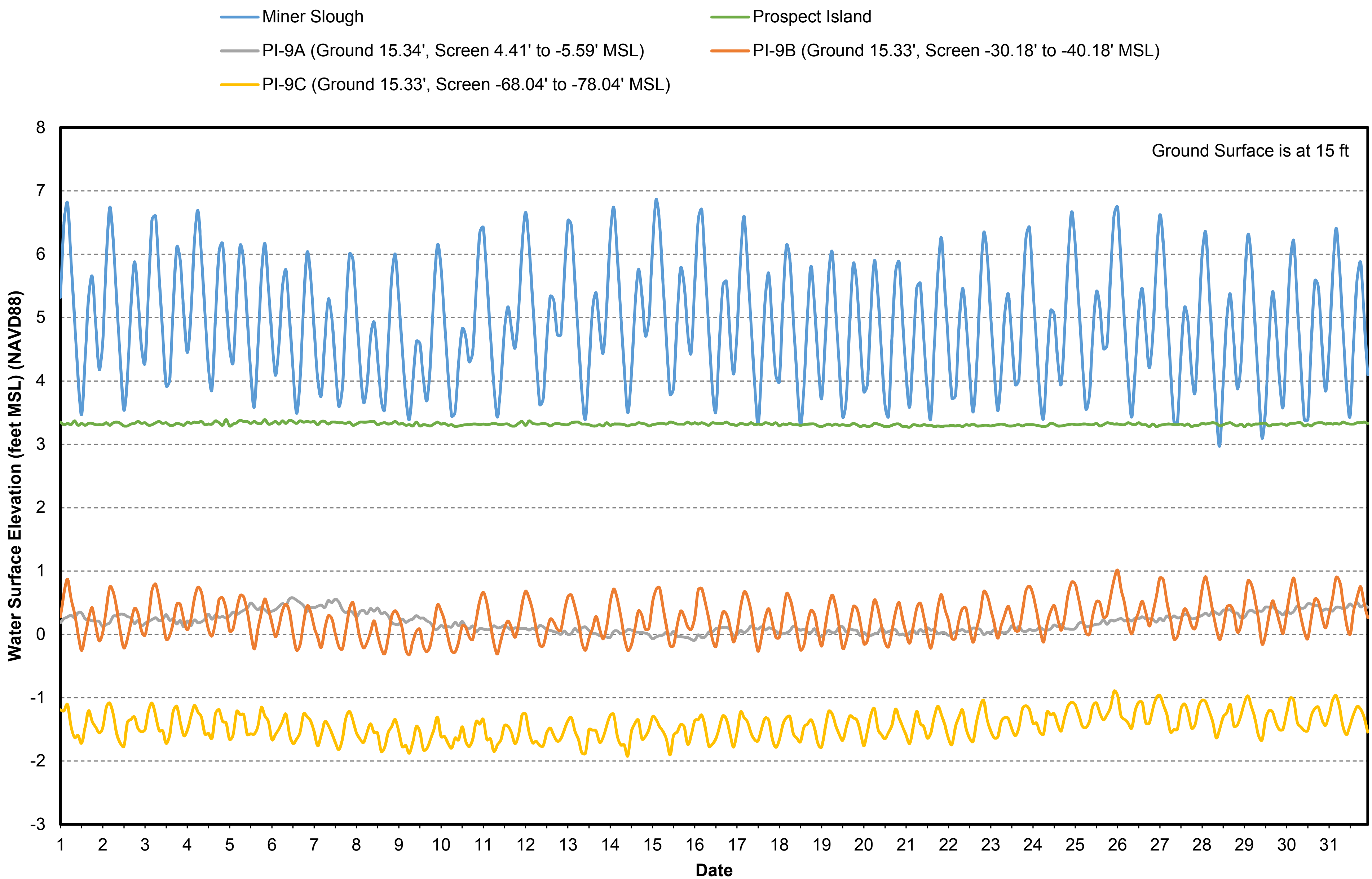


Figure 11-21

Hydrographs of Miner Slough, Prospect Island Surface Water Stage and Prospect Island PI-10A and -10B Groundwater Levels

Two Hour Water Levels - August 2012

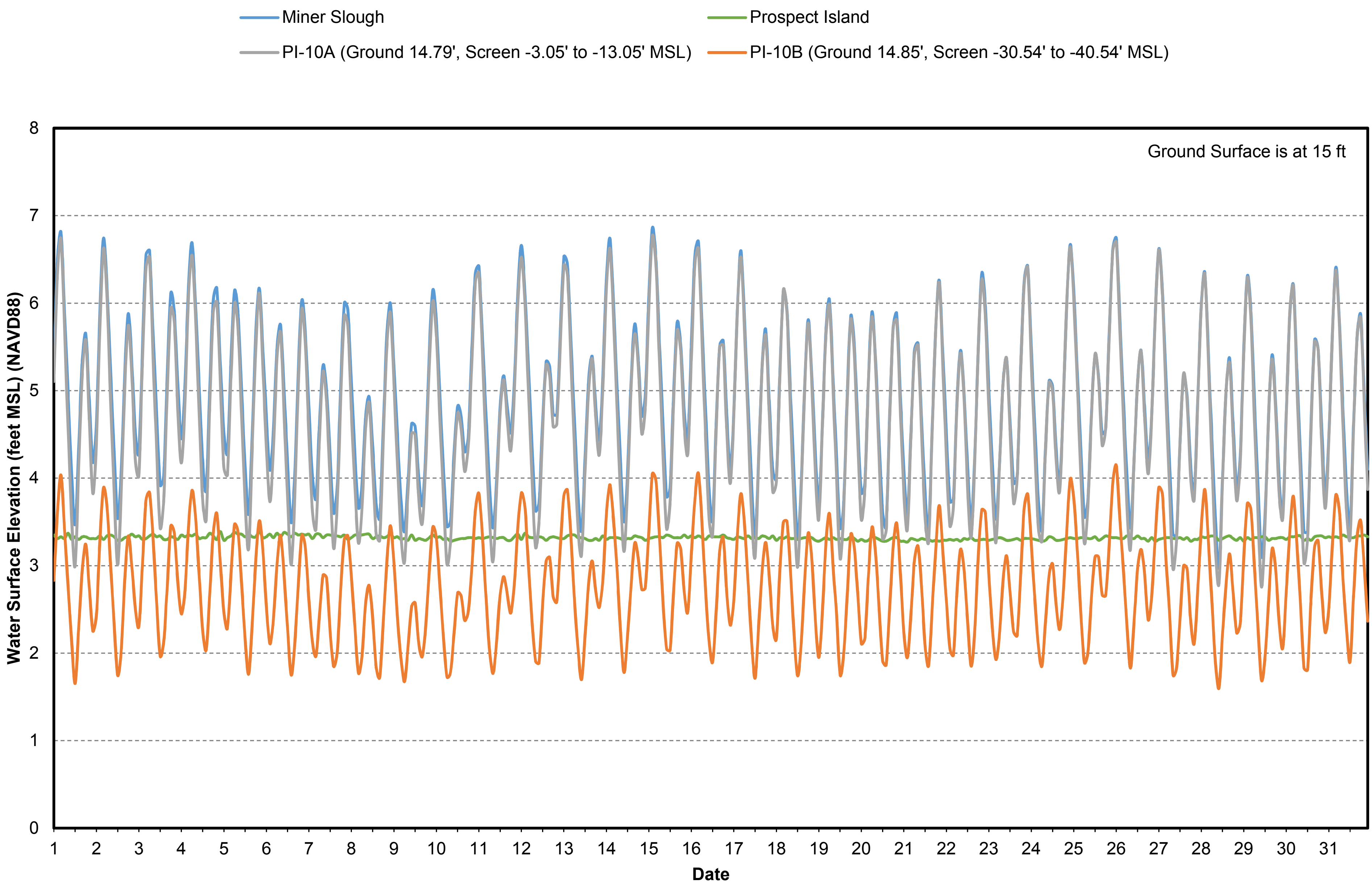


Figure 11-22

Hydrographs of Miner Slough, Prospect Island Surface Water Stage and Prospect Island PI-1A and -1B Groundwater Levels

Two Hour Water Levels - August 2012

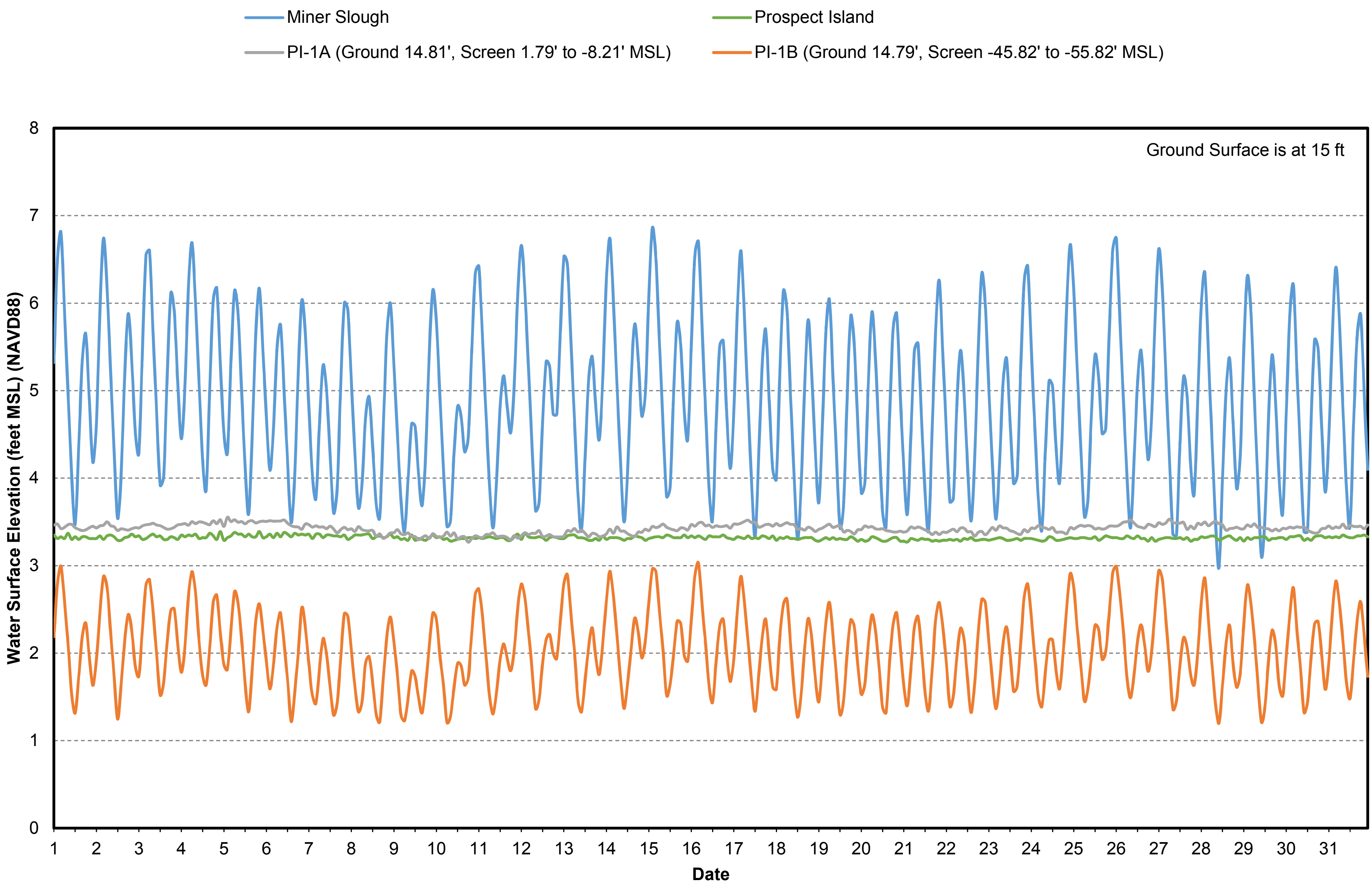


Figure 11-23

Hydrographs of Miner Slough, Prospect Island Surface Water Stage and Prospect Island PI-6A and -6B Groundwater Levels with Precipitation at Georgiana Slough

Two Hour Water Levels, Daily Precipitation - November 28 through December 31, 2012

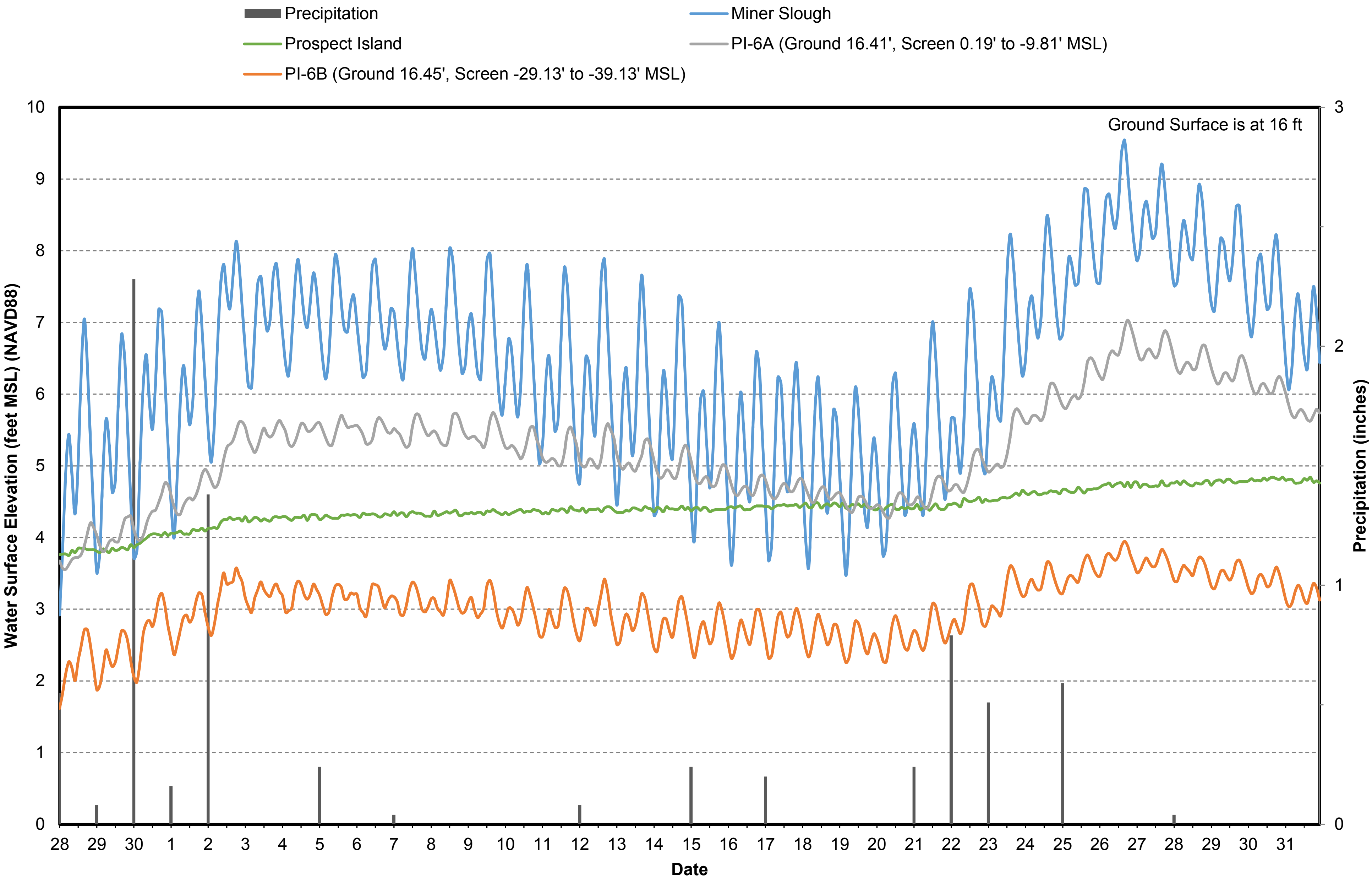


Figure 11-24

Hydrographs of Miner Slough, Prospect Island Surface Water Stage and Prospect Island PI-7A and -7B Groundwater Levels with Precipitation at Georgiana Slough

Two Hour Water Levels, Daily Precipitation - November 28 through December 31, 2012

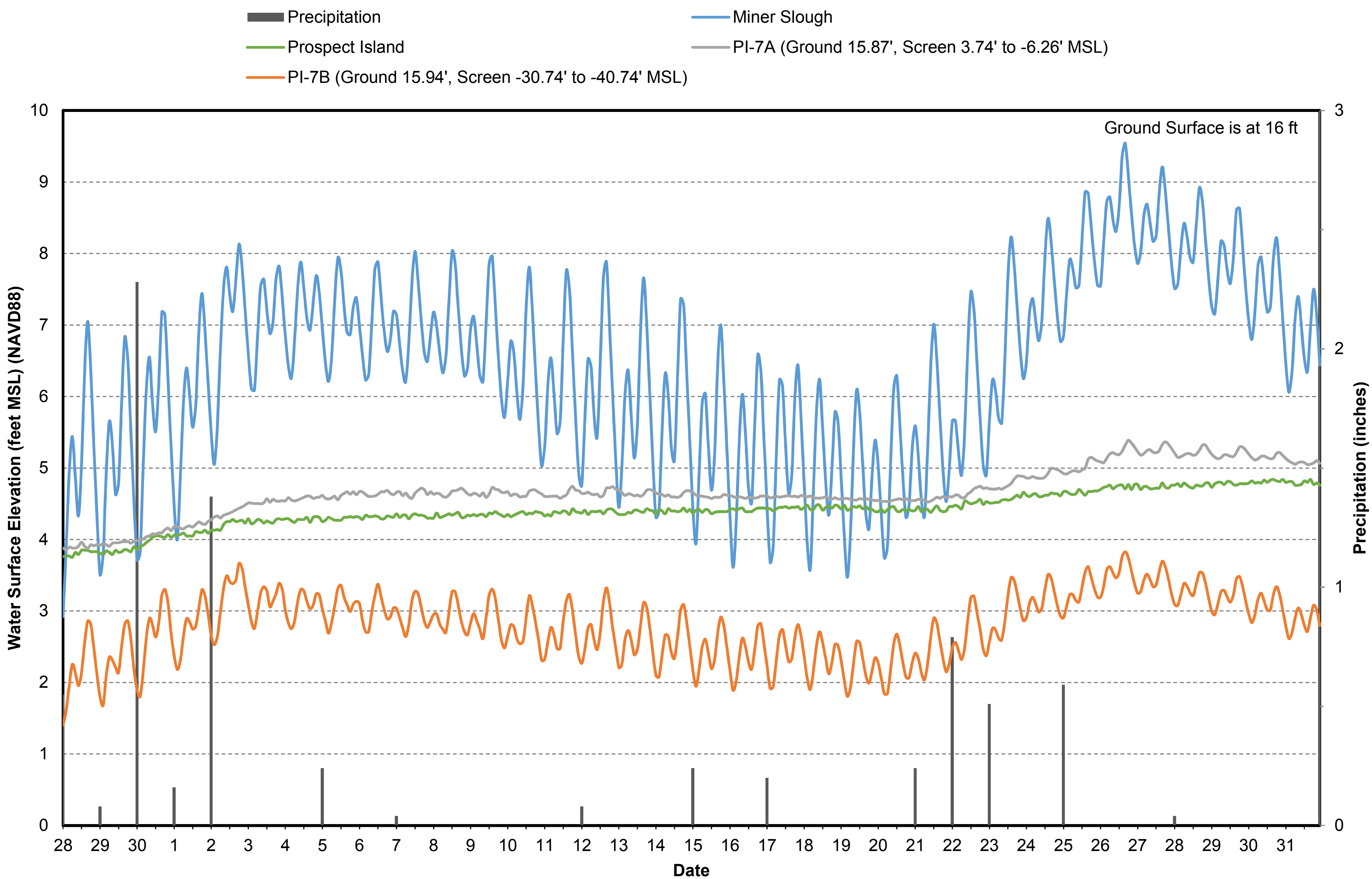


Figure 11-25

Hydrographs of Miner Slough, Prospect Island Surface Water Stage and Prospect Island PI-8A and -8B Groundwater Levels with Precipitation at Georgiana Slough

Two Hour Water Levels, Daily Precipitation - November 28 through December 31, 2012

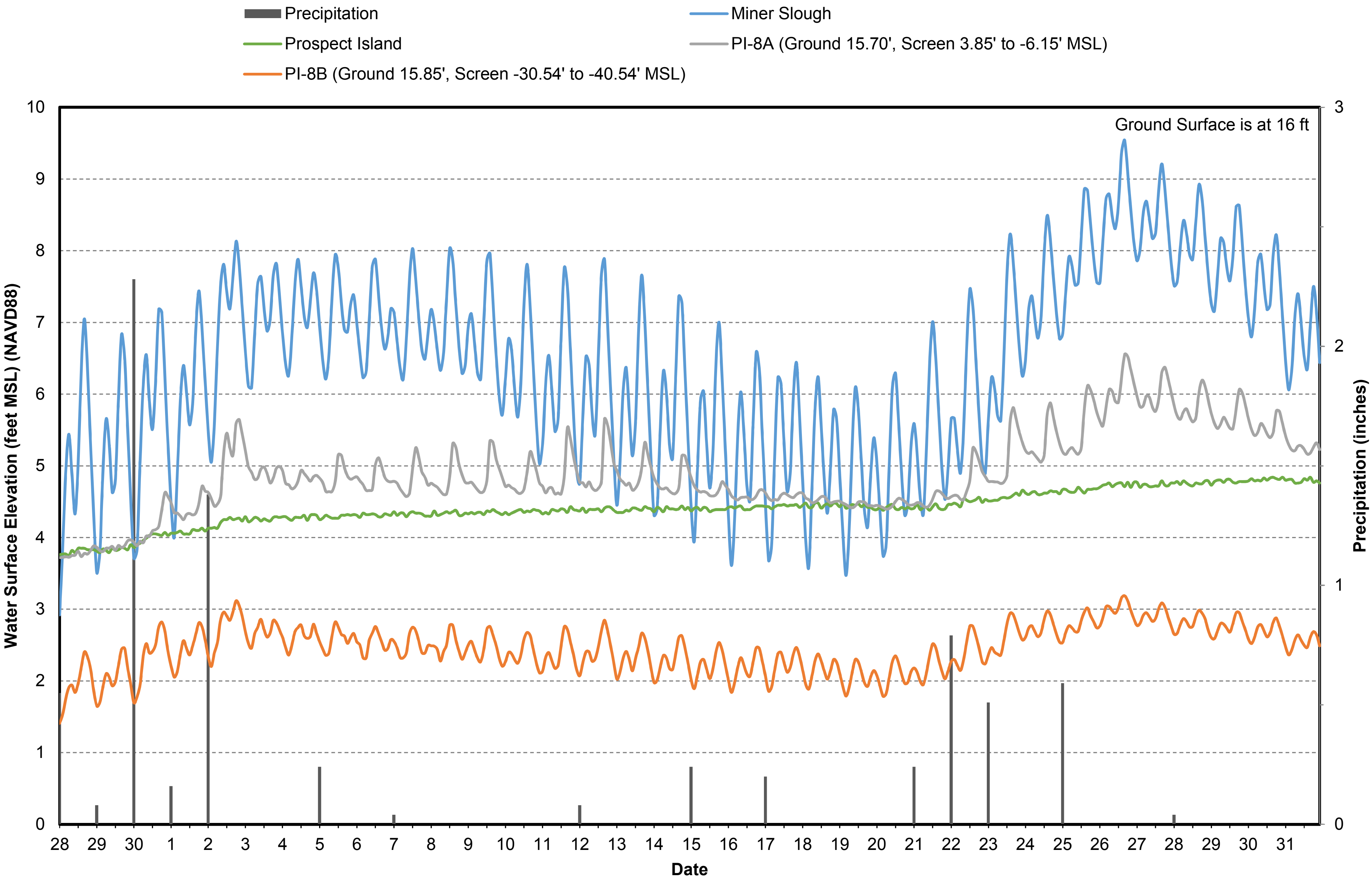


Figure 11-26

Hydrographs of Miner Slough, Prospect Island Surface Water Stage and Prospect Island PI-9A, -9B and -9C Groundwater Levels with Precipitation at Georgiana Slough

Two Hour Water Levels, Daily Precipitation - November 28 through December 31, 2012

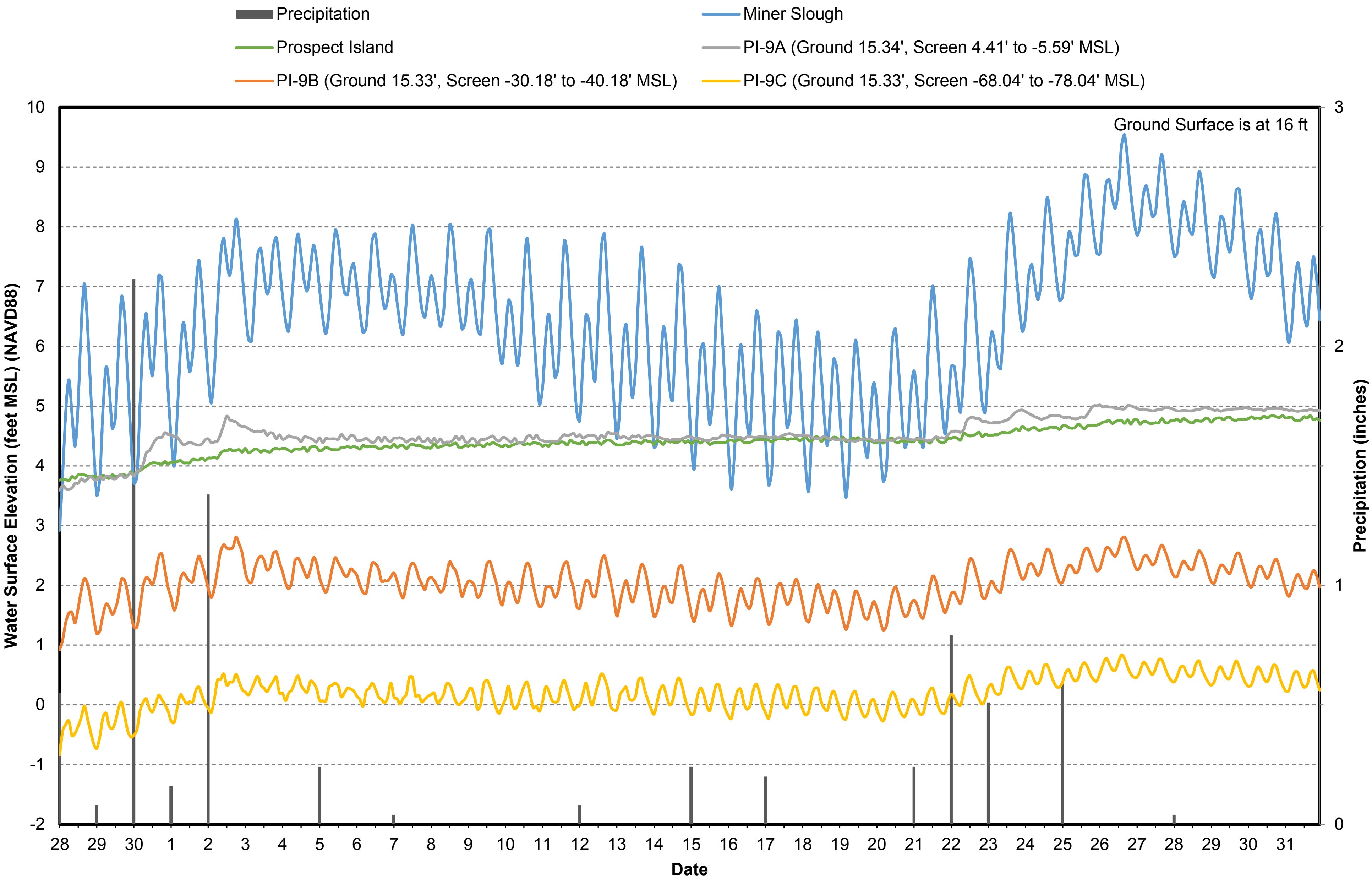


Figure 11-27

Hydrographs of Miner Slough, Prospect Island Surface Water Stage and Prospect Island PI-10A and -10B Groundwater Levels with Precipitation at Georgiana Slough

Two Hour Water Levels, Daily Precipitation - November 28 through December 31, 2012

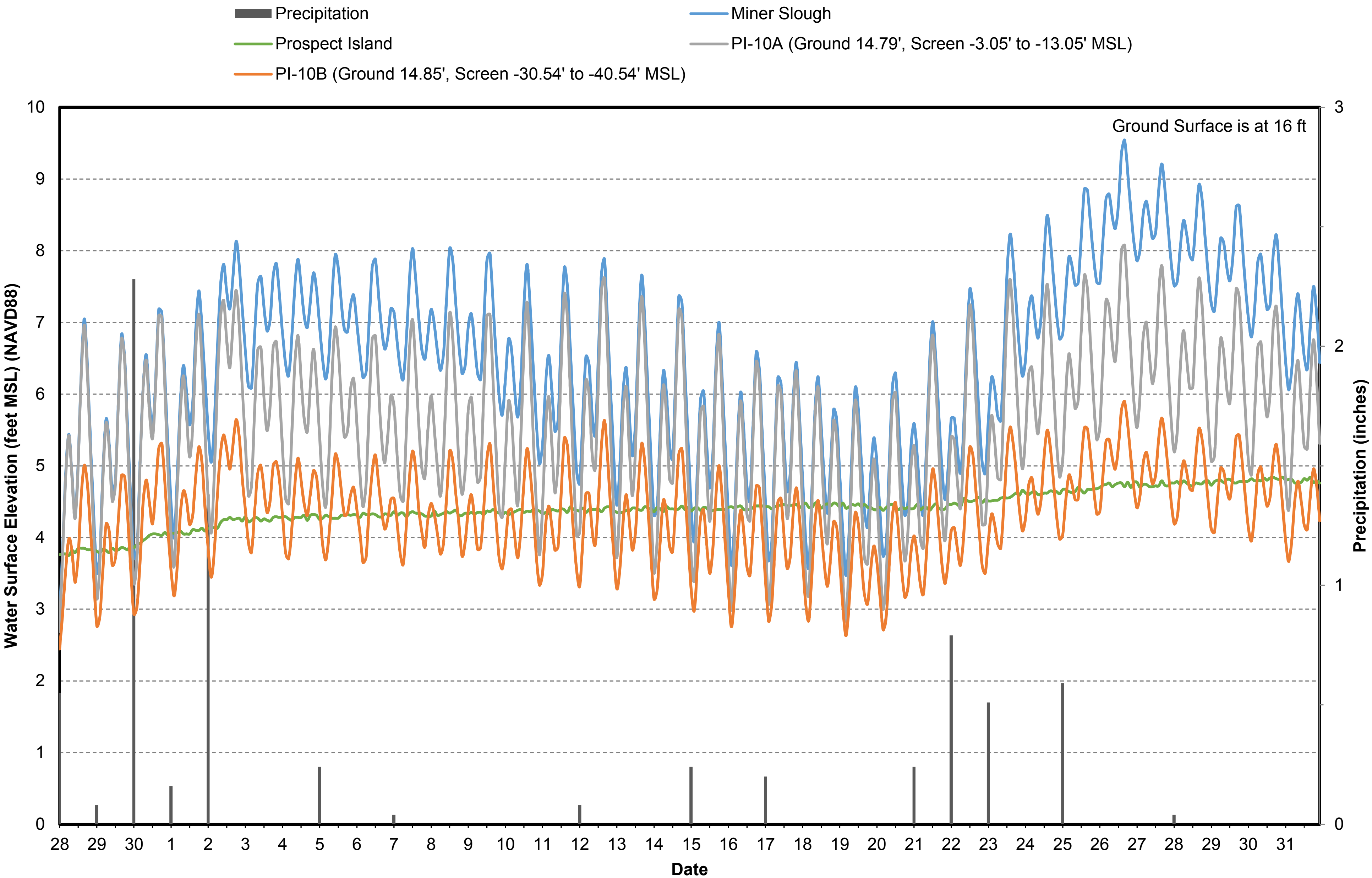


Figure 11-28

Hydrographs of Miner Slough, Prospect Island Surface Water Stage and Prospect Island PI-1A and -1B Groundwater Levels with Precipitation at Georgiana Slough

Two Hour Water Levels, Daily Precipitation - November 28 through December 31, 2012

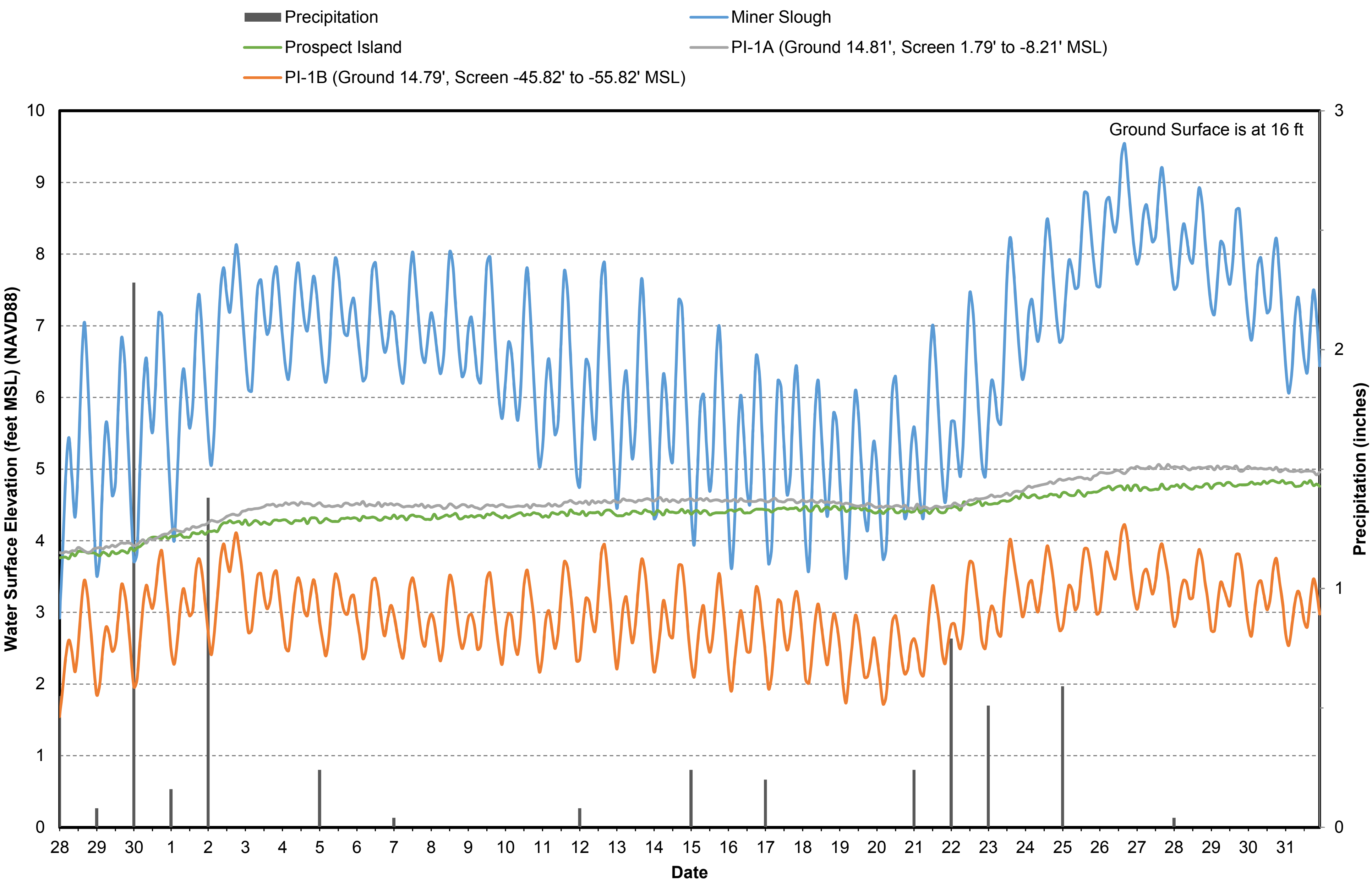


Figure 11-29

Hydrographs of Miner Slough and Prospect Island Surface Water Stage, Ryer Island MW 99-1 and -2 Groundwater Levels with Precipitation at Georgiana Slough

Daily Mean Water Levels, Daily Precipitation - December 21, 2011 to October 1, 2013

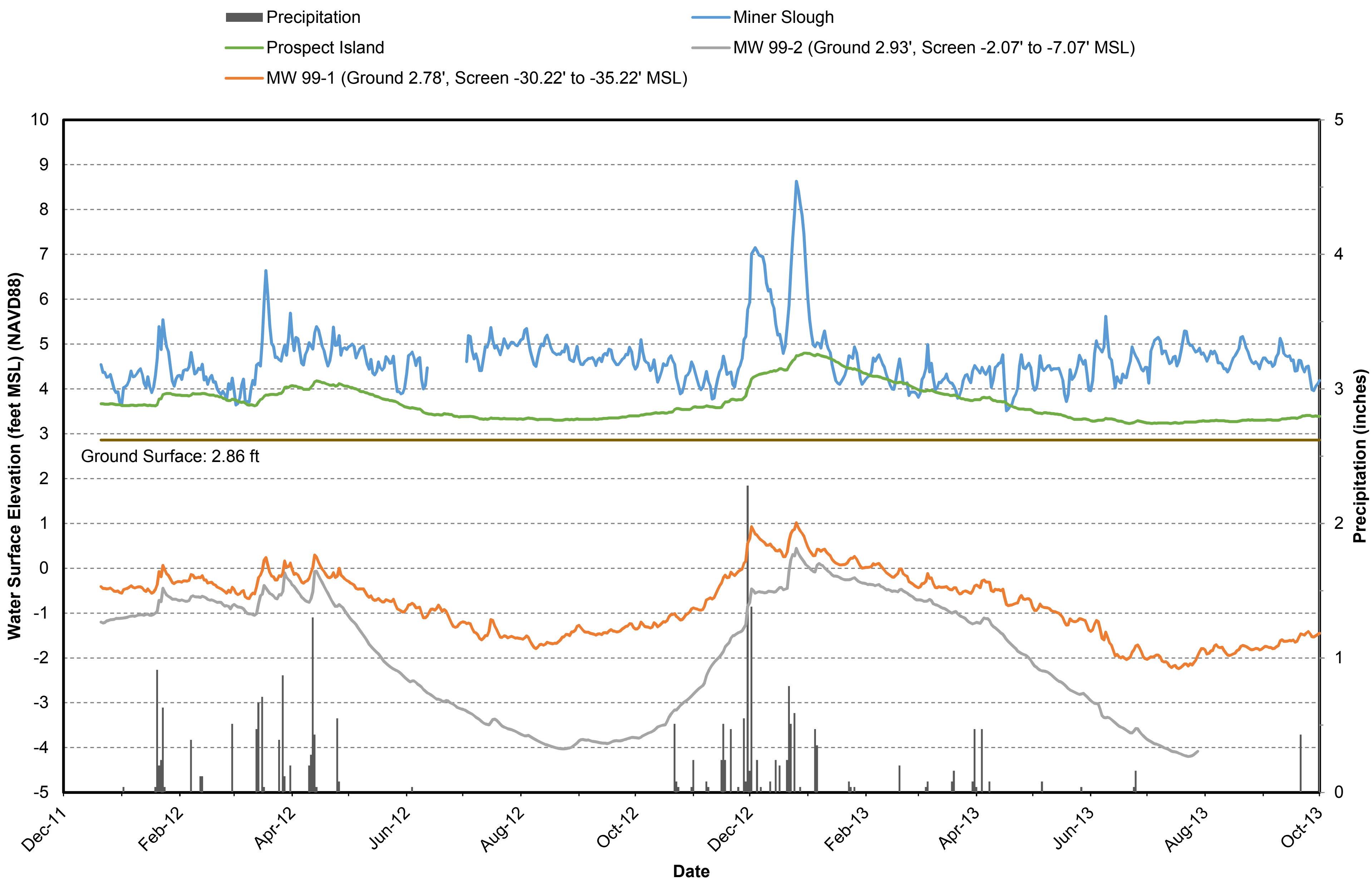


Figure 11-30

Hydrographs of Miner Slough Stage and Prospect Island Stage, Ryer Island MW 99-1 and -2 Groundwater Levels

Two Hour Water Levels - August 2012

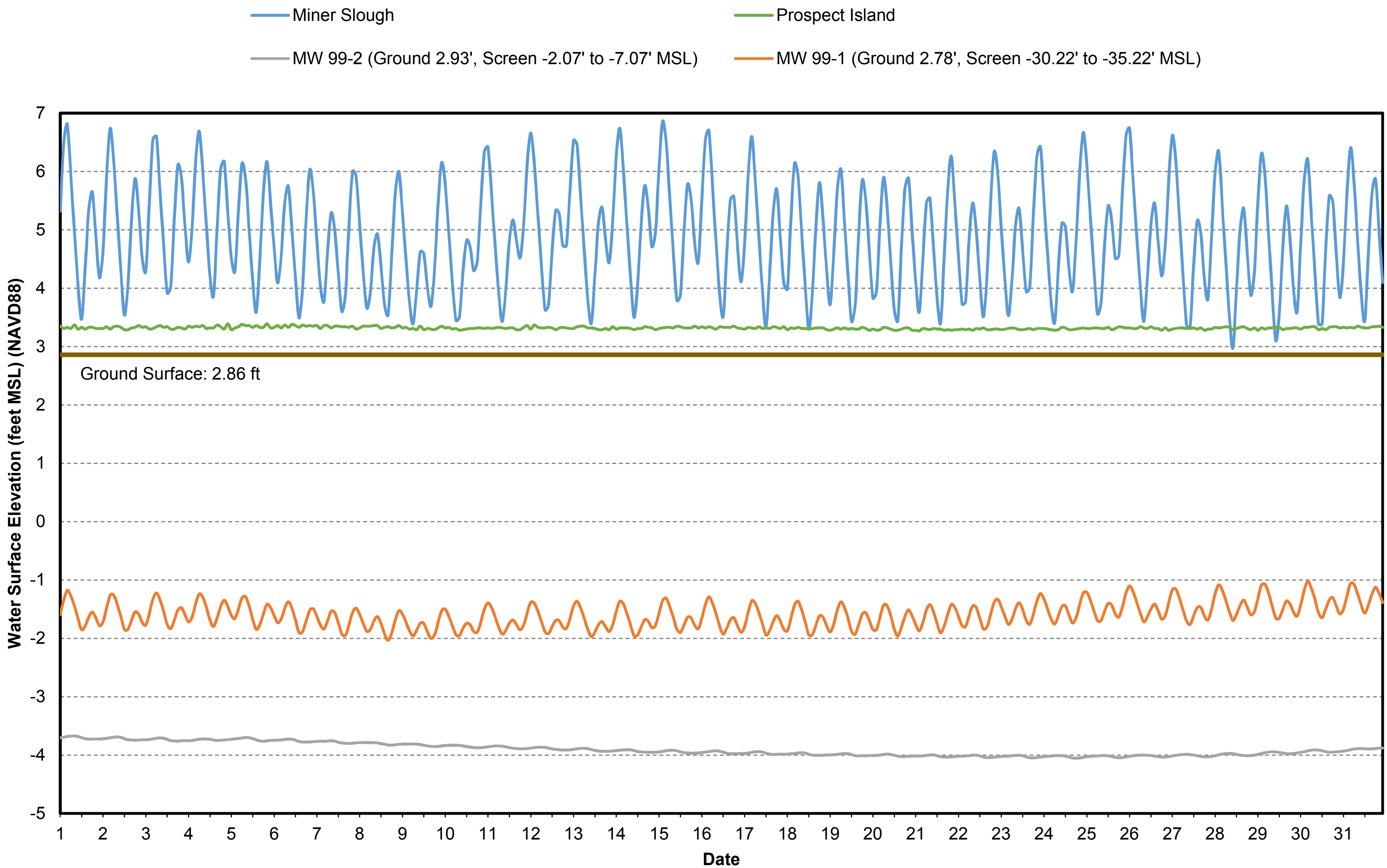


Figure 11-31

Hydrographs of Miner Slough Stage and Prospect Island Stage, Ryer Island MW 99-1 and -2 Groundwater Levels with Precipitation at Georgiana Slough

Two Hour Water Levels, Daily Precipitation - November 28 through December 31, 2012

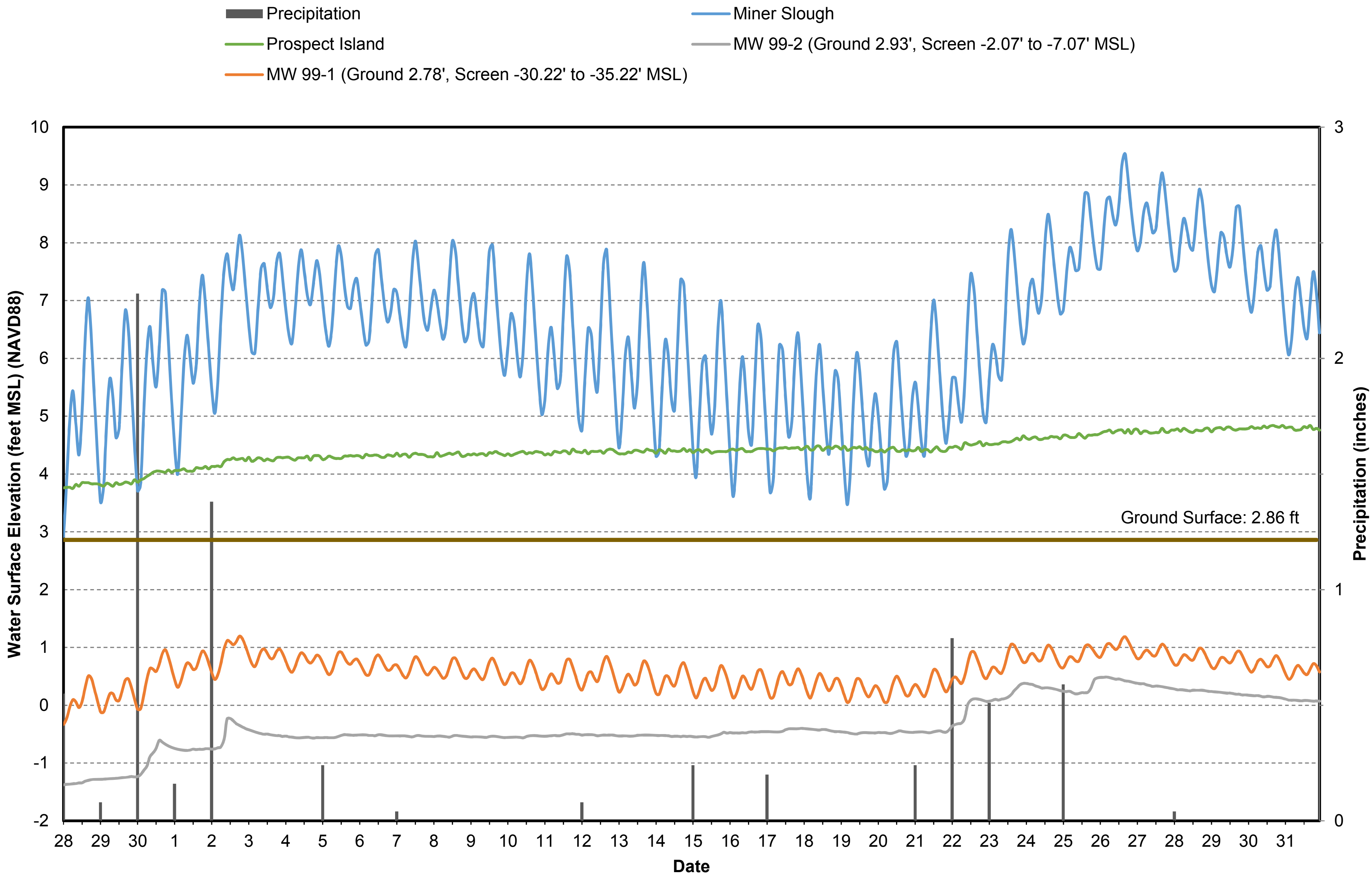


Figure 11-32

Hydrographs of Miner Slough Stage and Prospect Island Stage, Ryer Island MW 99-3 and -4 Groundwater Levels with Precipitation at Georgiana Slough

Daily Mean Water Levels, Daily Precipitation - December 21, 2011 to October 1, 2013

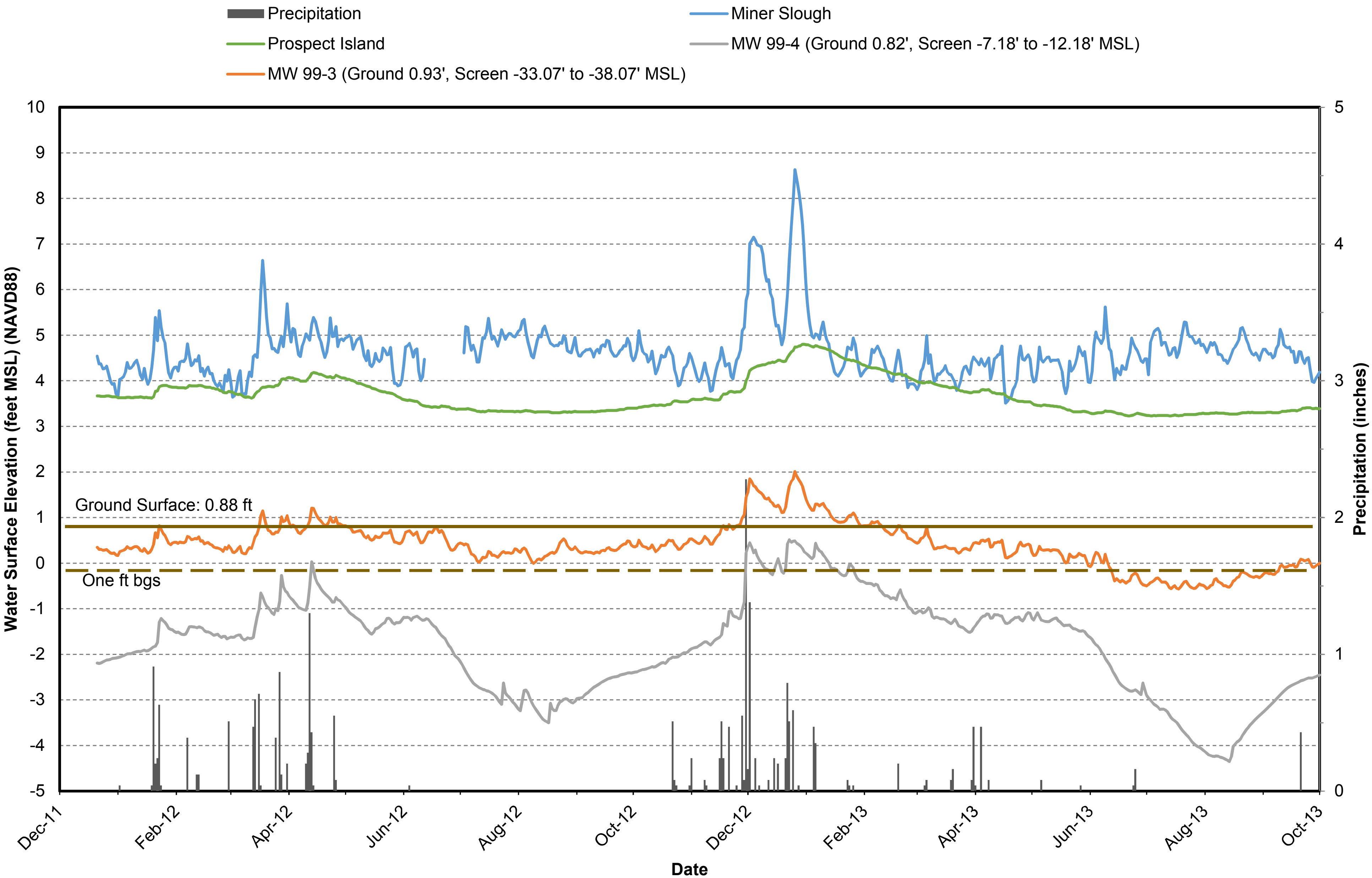


Figure 11-33

Hydrographs of Miner Slough Stage and Prospect Island Stage,
Ryer Island MW 99-11 Groundwater Level with Precipitation at Georgiana Slough
Daily Mean Water Levels, Daily Precipitation - December 21, 2011 to October 1, 2013

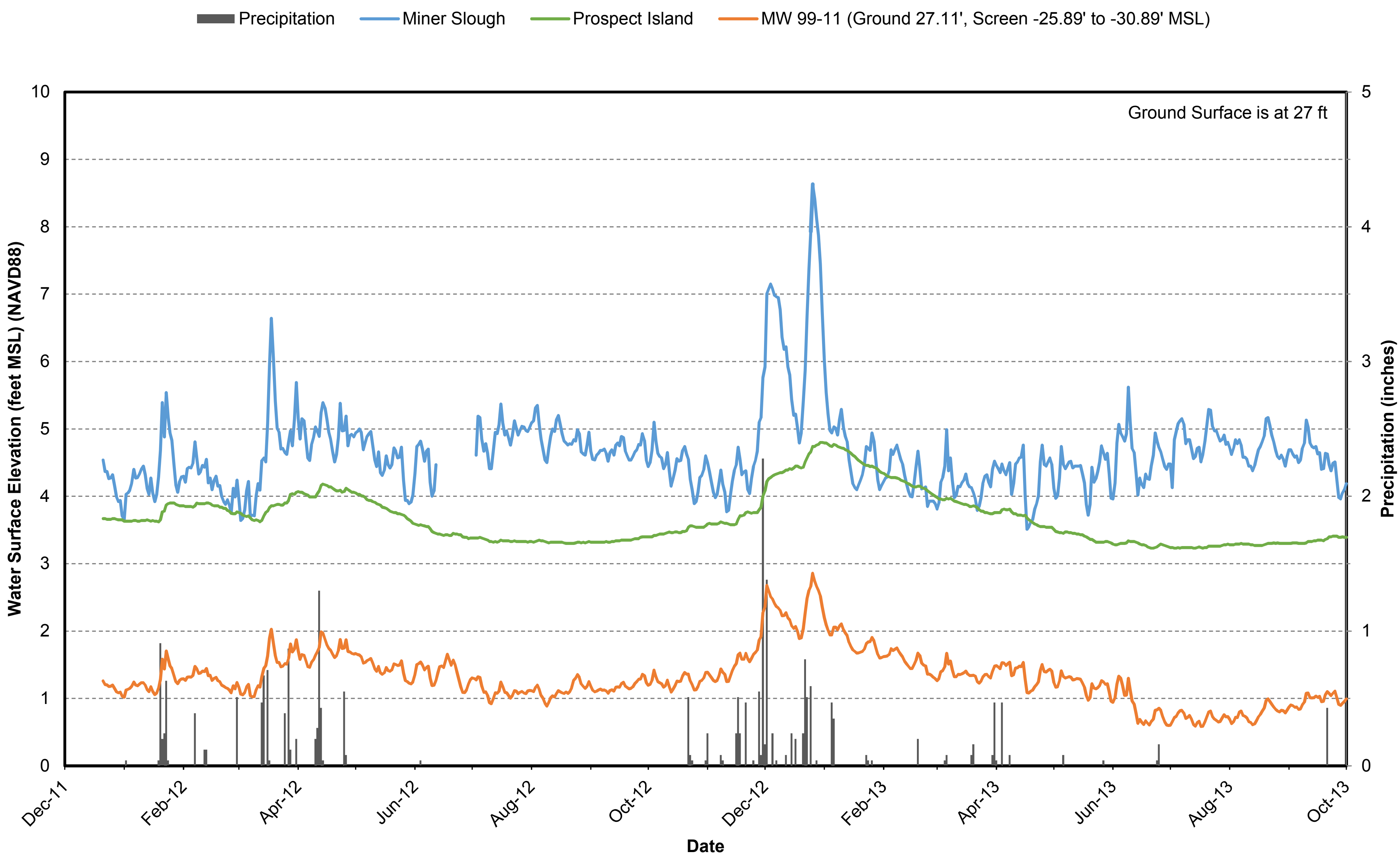


Figure 11-34

Hydrographs of Miner Slough Stage and Prospect Island Stage, Ryer Island MW 99-3 and -4 Groundwater Levels

Two Hour Water Levels - August 2012

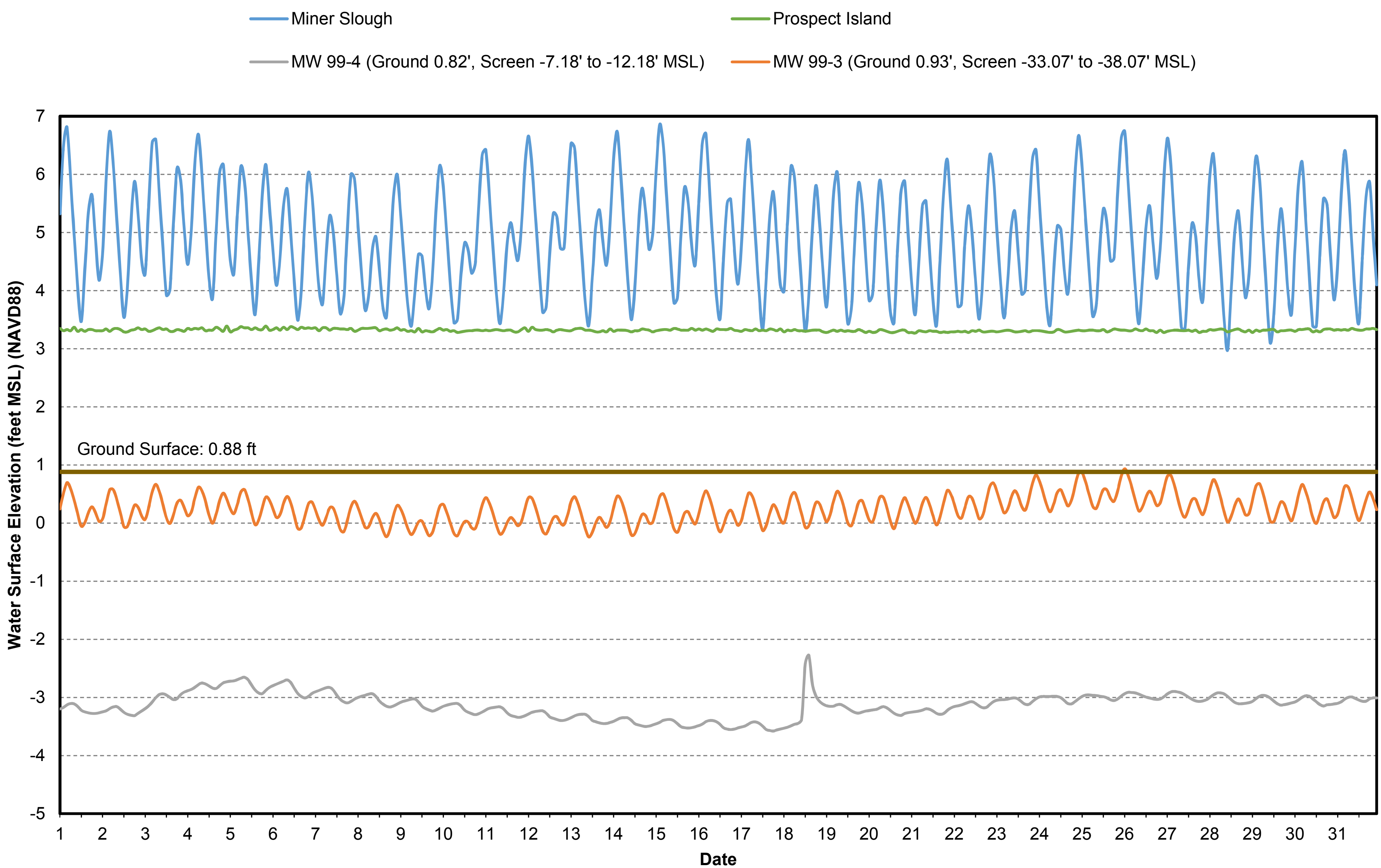


Figure 11-35

Hydrographs of Miner Slough Stage and Prospect Island Stage, Ryer Island MW 99-11 Groundwater Level

Two Hour Water Levels - August 2012

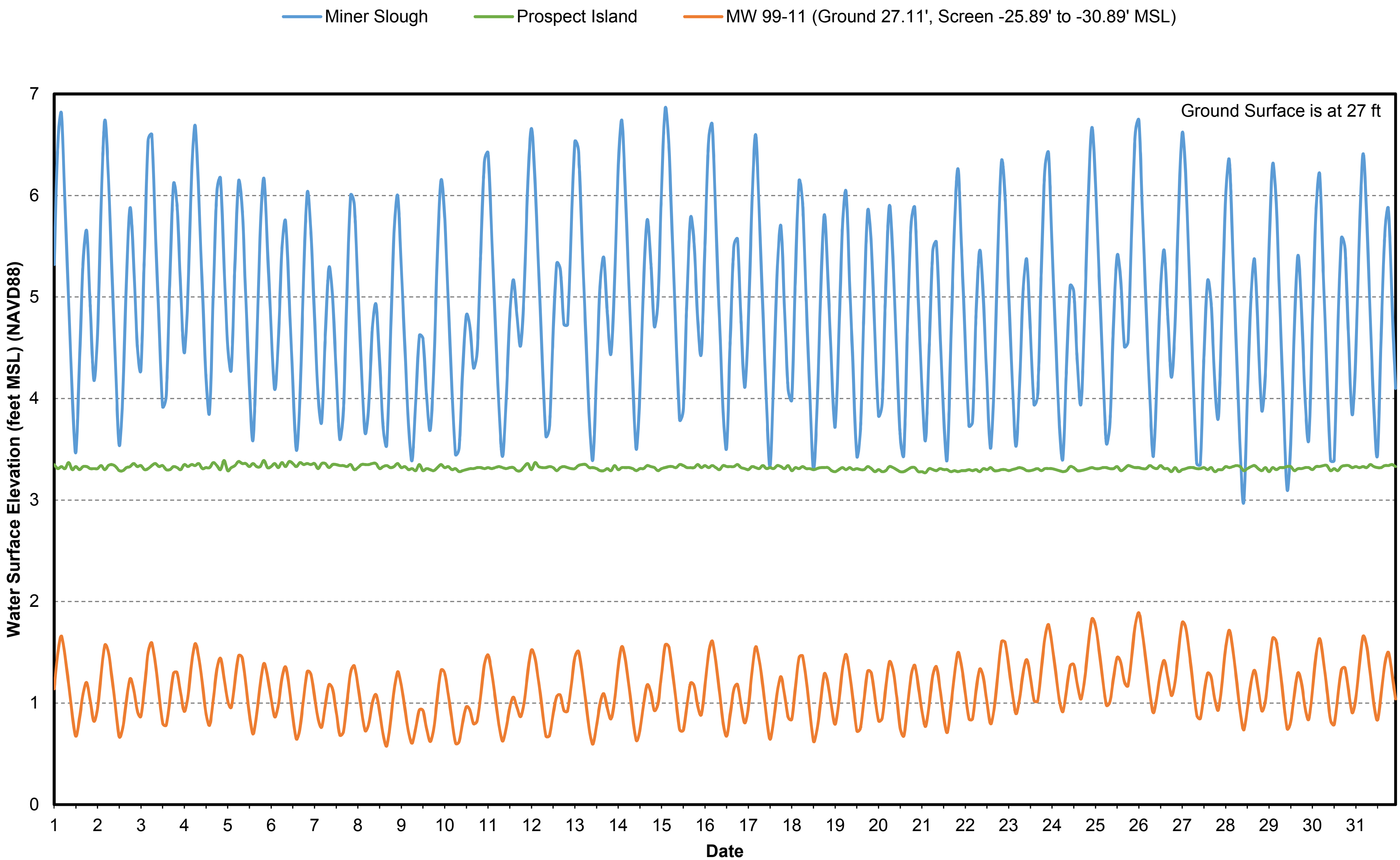


Figure 11-36

Hydrographs of Miner Slough Stage and Prospect Island Stage, Ryer Island MW 99-3 and -4 Groundwater Levels with Precipitation at Georgiana Slough

Two Hour Water Levels, Daily Precipitation - November 28 through December 31, 2012

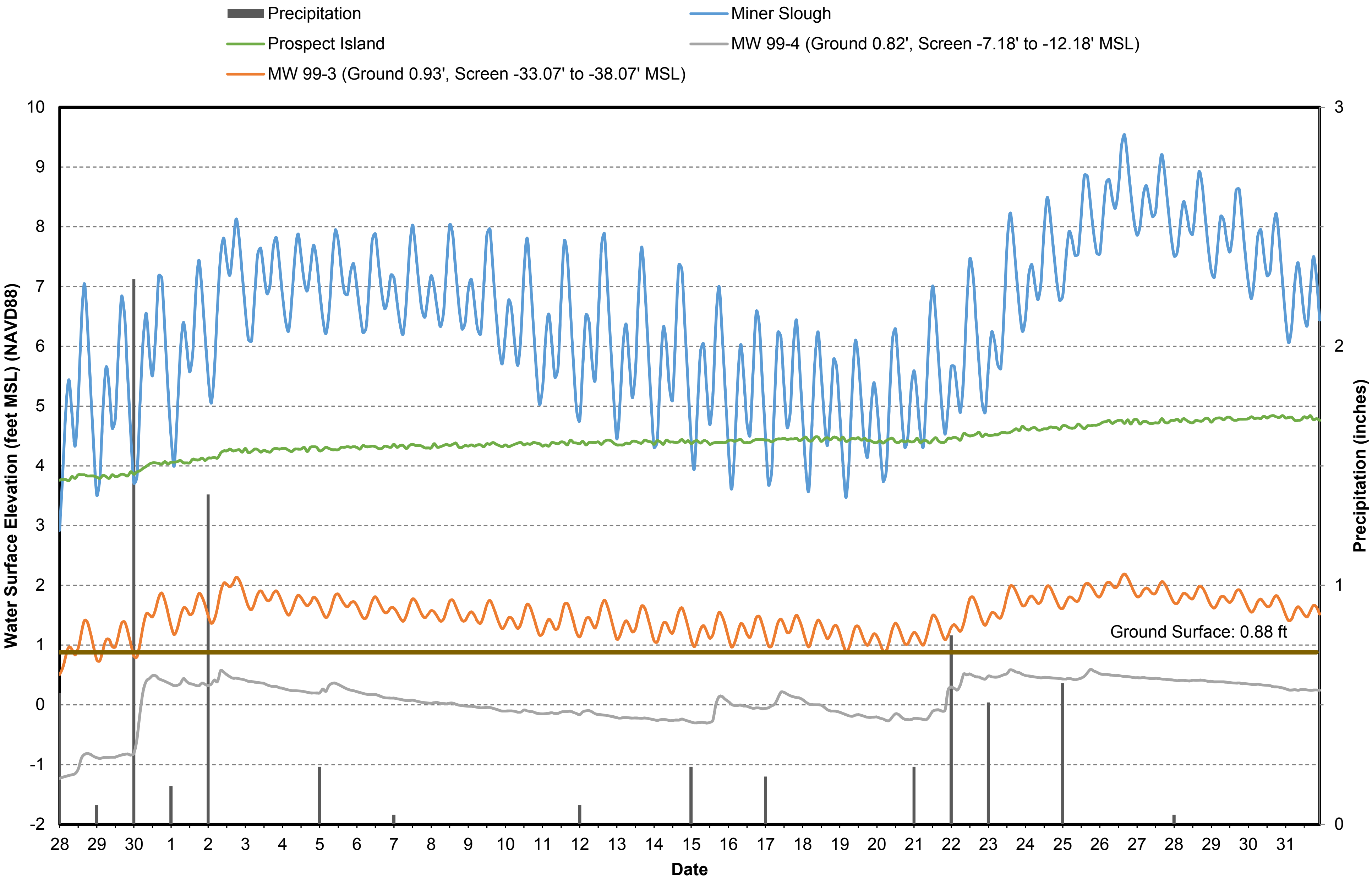


Figure 11-37

Hydrographs of Miner Slough Stage and Prospect Island Stage, Ryer Island MW 99-11 Groundwater Level with Precipitation at Georgiana Slough

Two Hour Water Levels, Daily Precipitation - November 28 through December 31, 2012

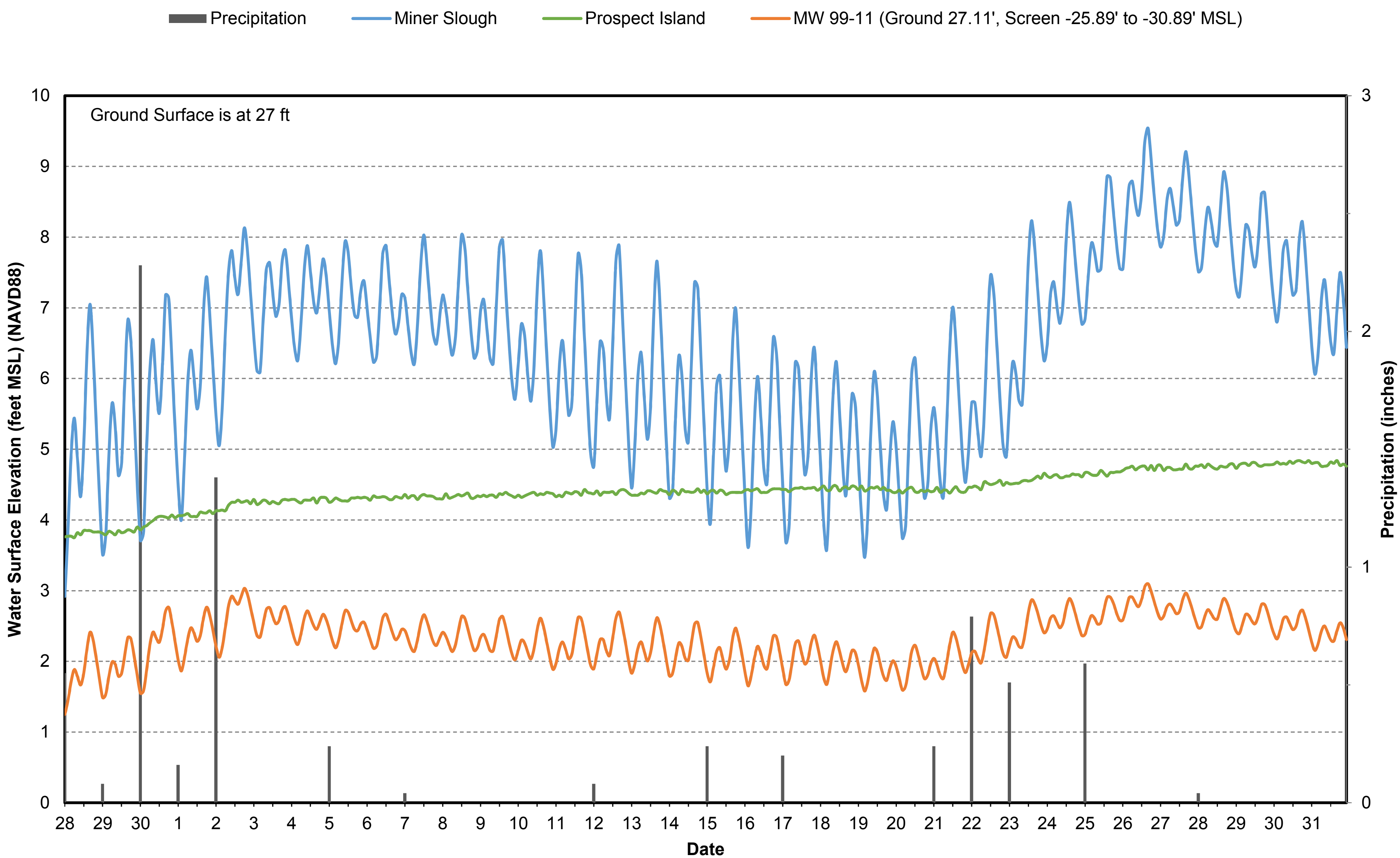


Figure 11-38

Hydrographs of Miner Slough Stage and Prospect Island Stage, Ryer Island MW 99-5 and -6 Groundwater Levels with Precipitation at Georgiana Slough

Daily Mean Water Levels, Daily Precipitation - December 21, 2011 to October 1, 2013

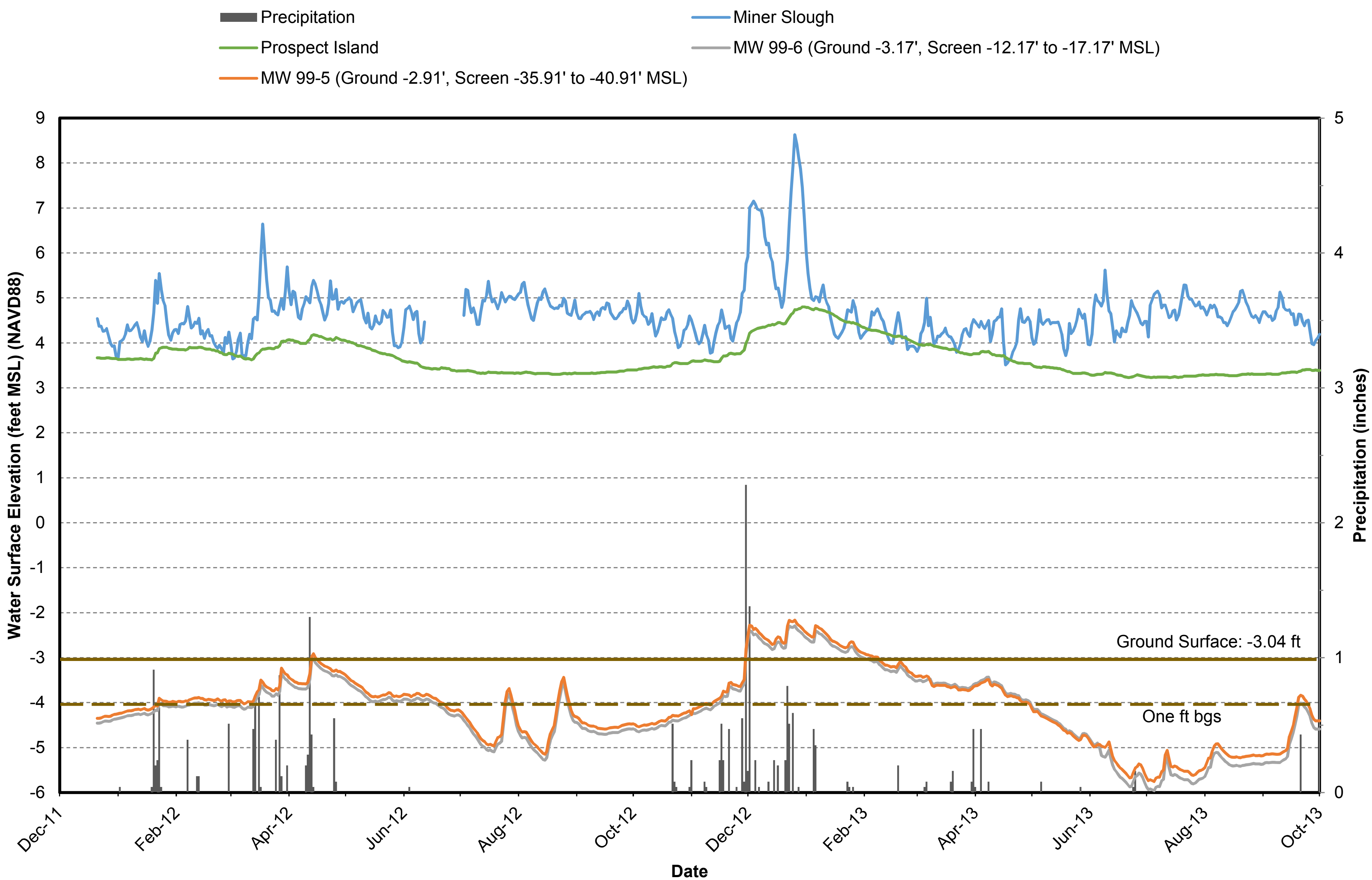


Figure 11-39

Hydrographs of Miner Slough Stage and Prospect Island Stage, Ryer Island MW 99-7 and -8 Groundwater Levels with Precipitation at Georgiana Slough

Daily Mean Water Levels, Daily Precipitation - December 21, 2011 to October 1, 2013

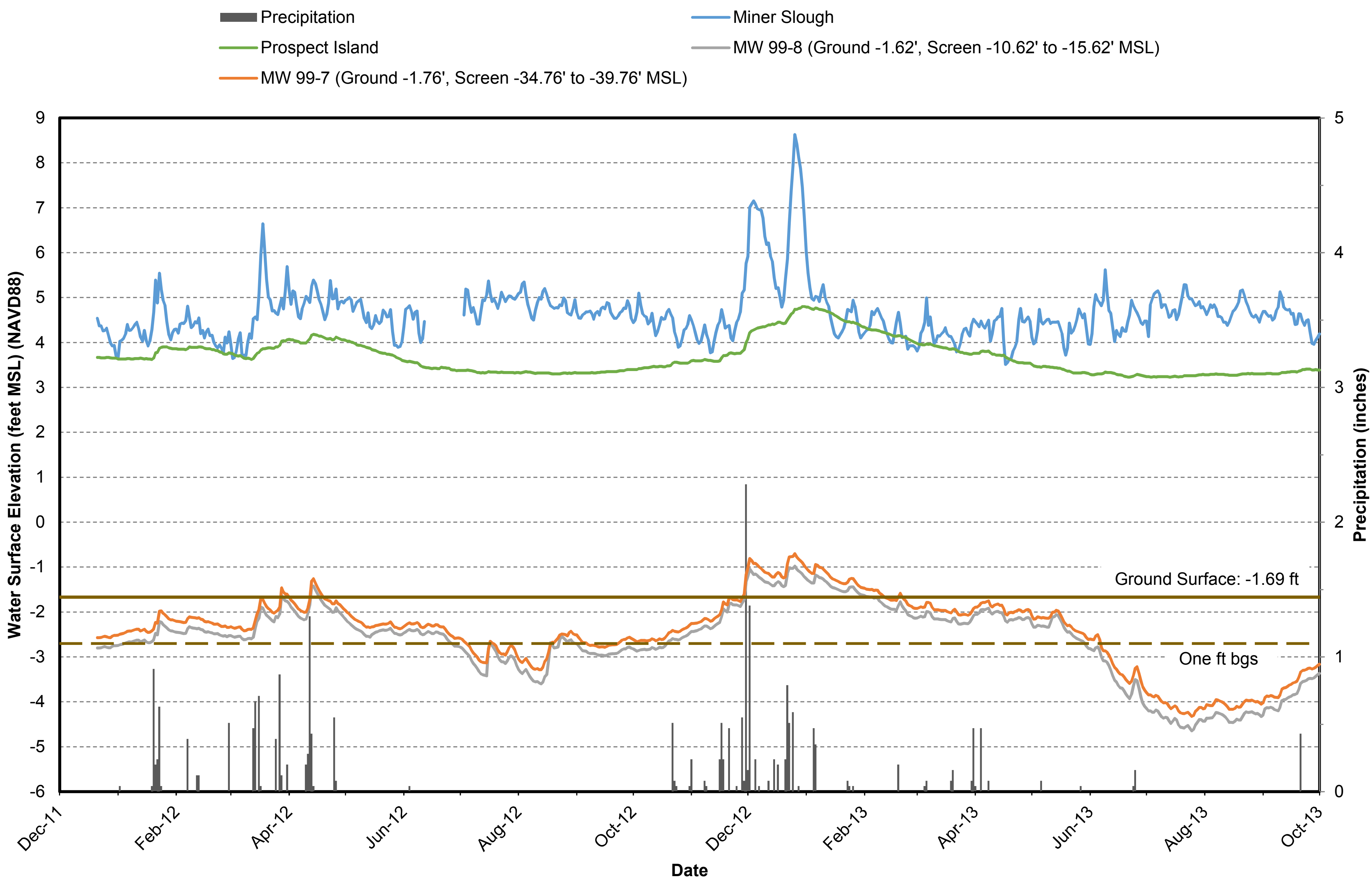


Figure 11-40

Hydrographs of Miner Slough Stage and Prospect Island Stage, Ryer Island MW 99-5 and -6 Groundwater Levels

Two Hour Water Levels - August 2012

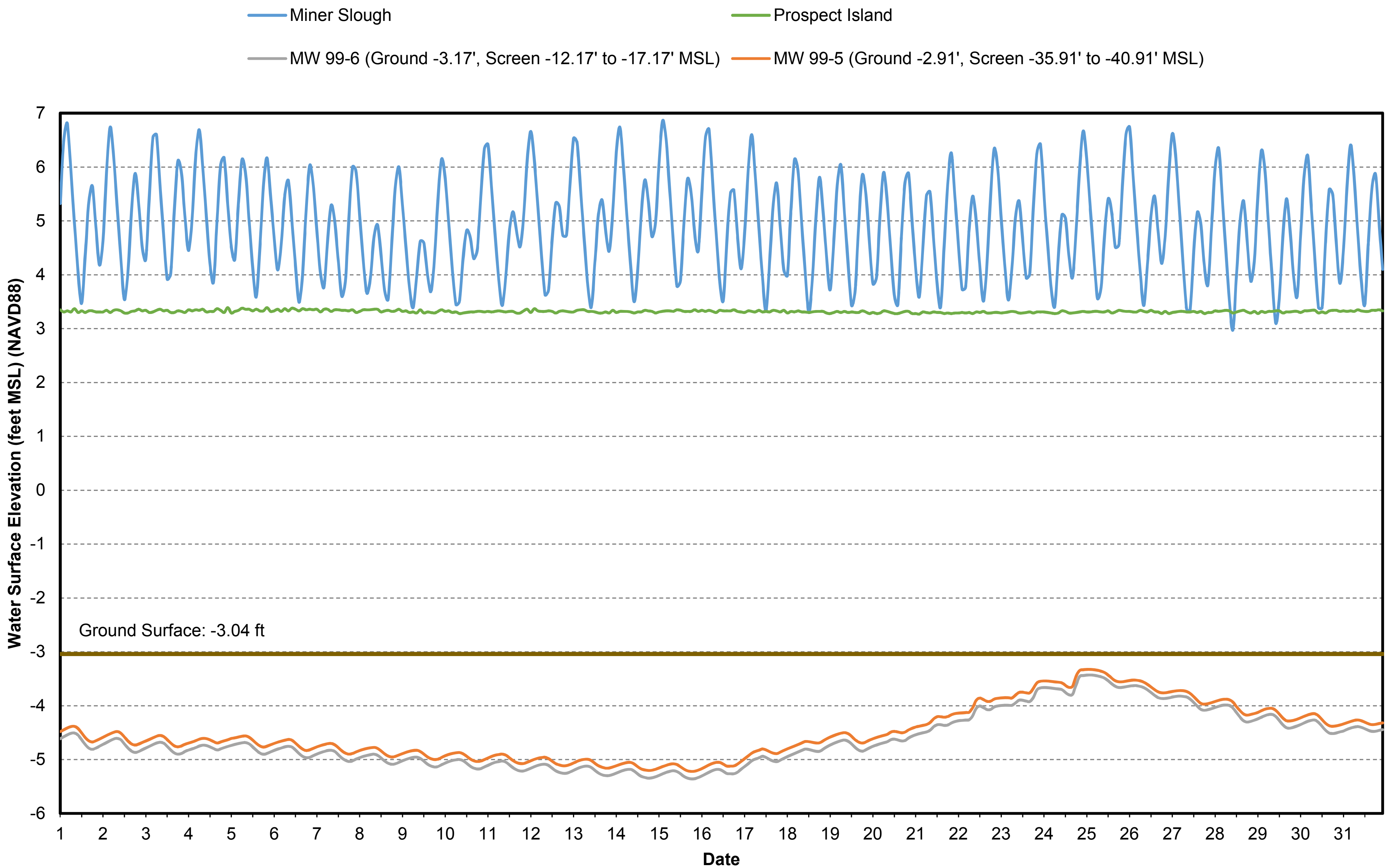


Figure 11-41

Hydrographs of Miner Slough Stage and Prospect Island Stage, Ryer Island MW 99-7 and -8 Groundwater Levels

Two Hour Water Levels - August 2012

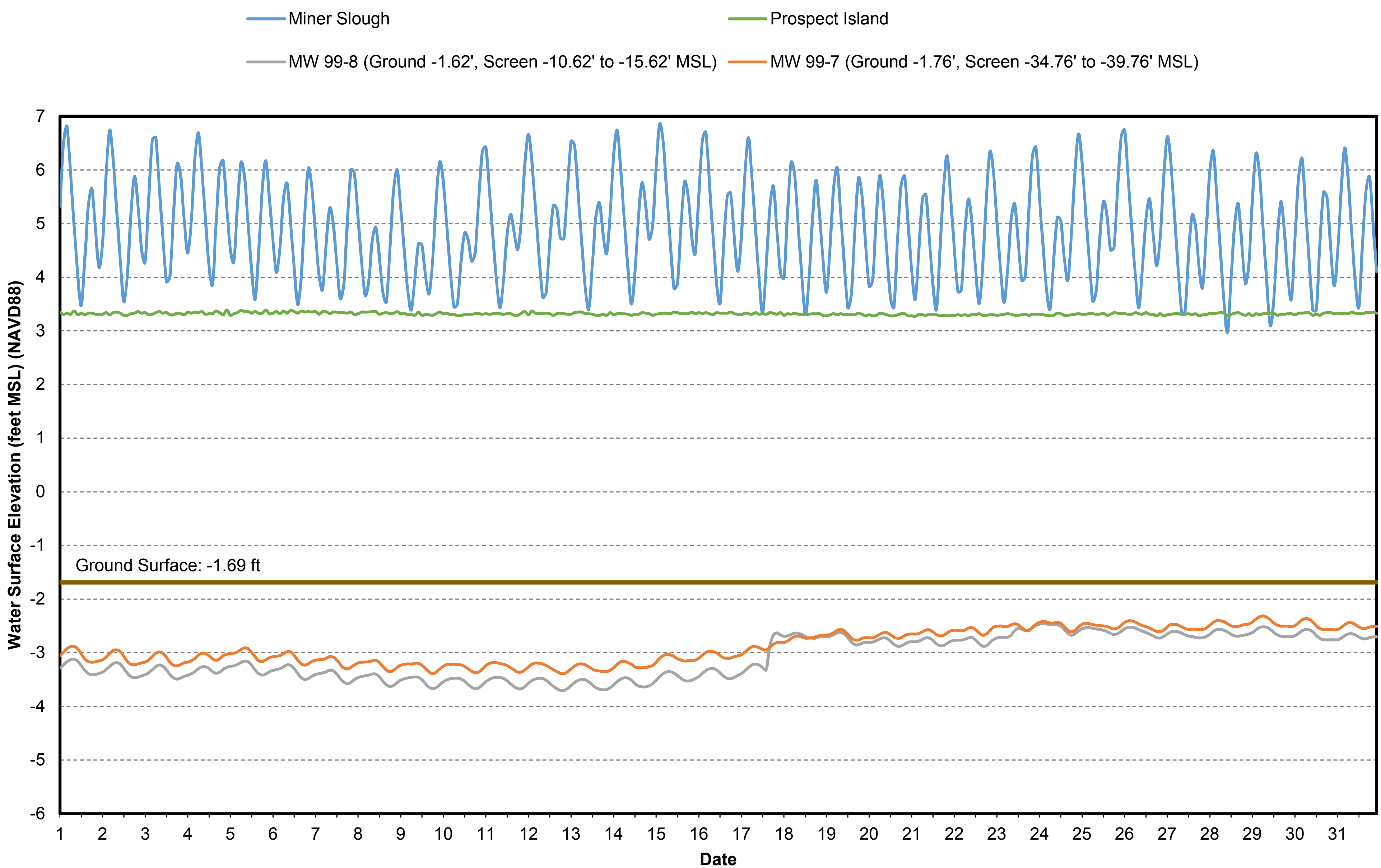


Figure 11-42

Hydrographs of Miner Slough Stage and Prospect Island Stage, Ryer Island MW 99-5 and -6 Groundwater Levels with Precipitation at Georgiana Slough

Two Hour Water Levels, Daily Precipitation - November 28 through December 31, 2012

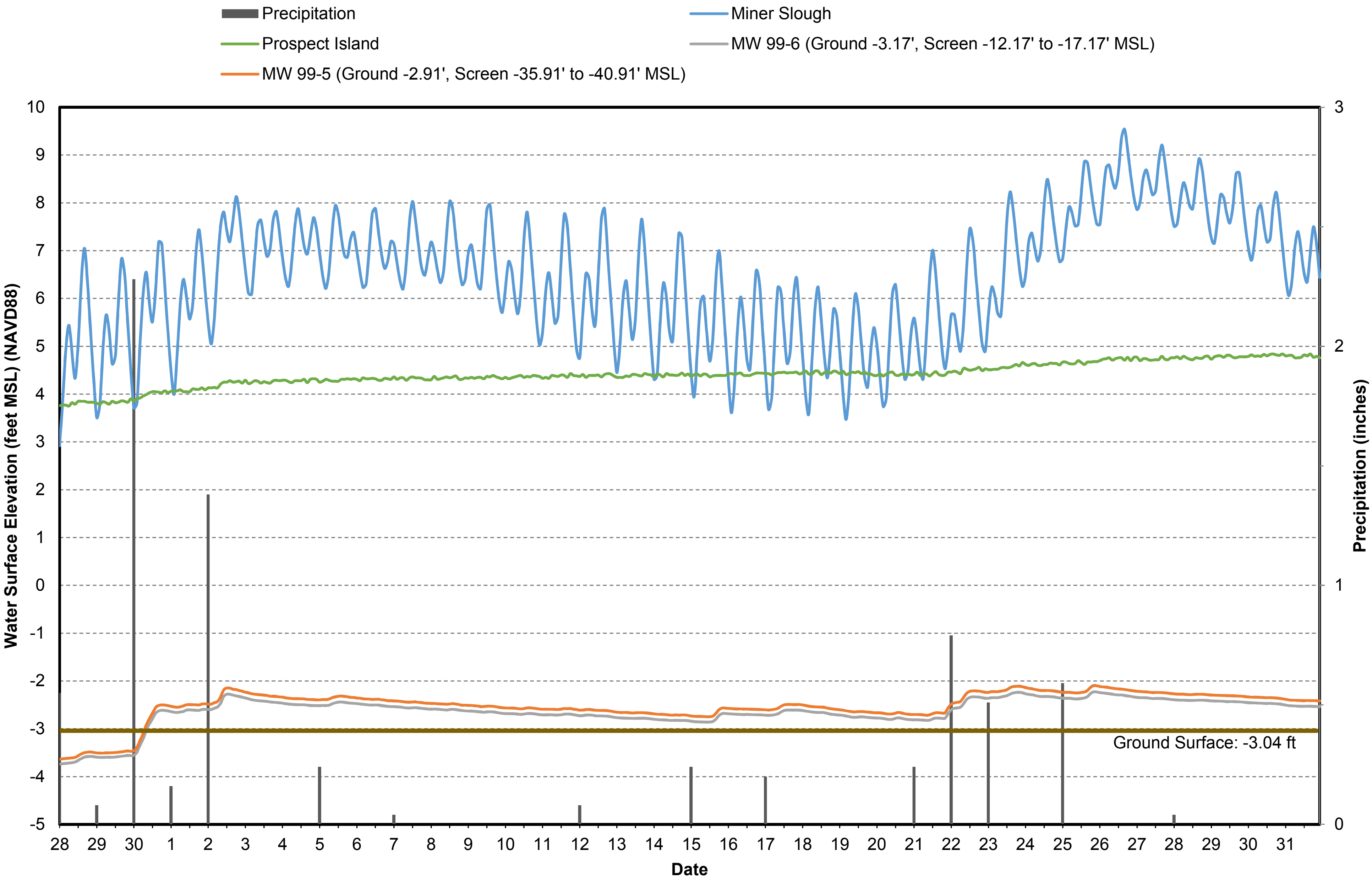


Figure 11-43

Hydrographs of Miner Slough Stage and Prospect Island Stage, Ryer Island MW 99-7 and -8 Groundwater Levels with Precipitation at Georgiana Slough

Two Hour Water Levels, Daily Precipitation - November 28 through December 31, 2012

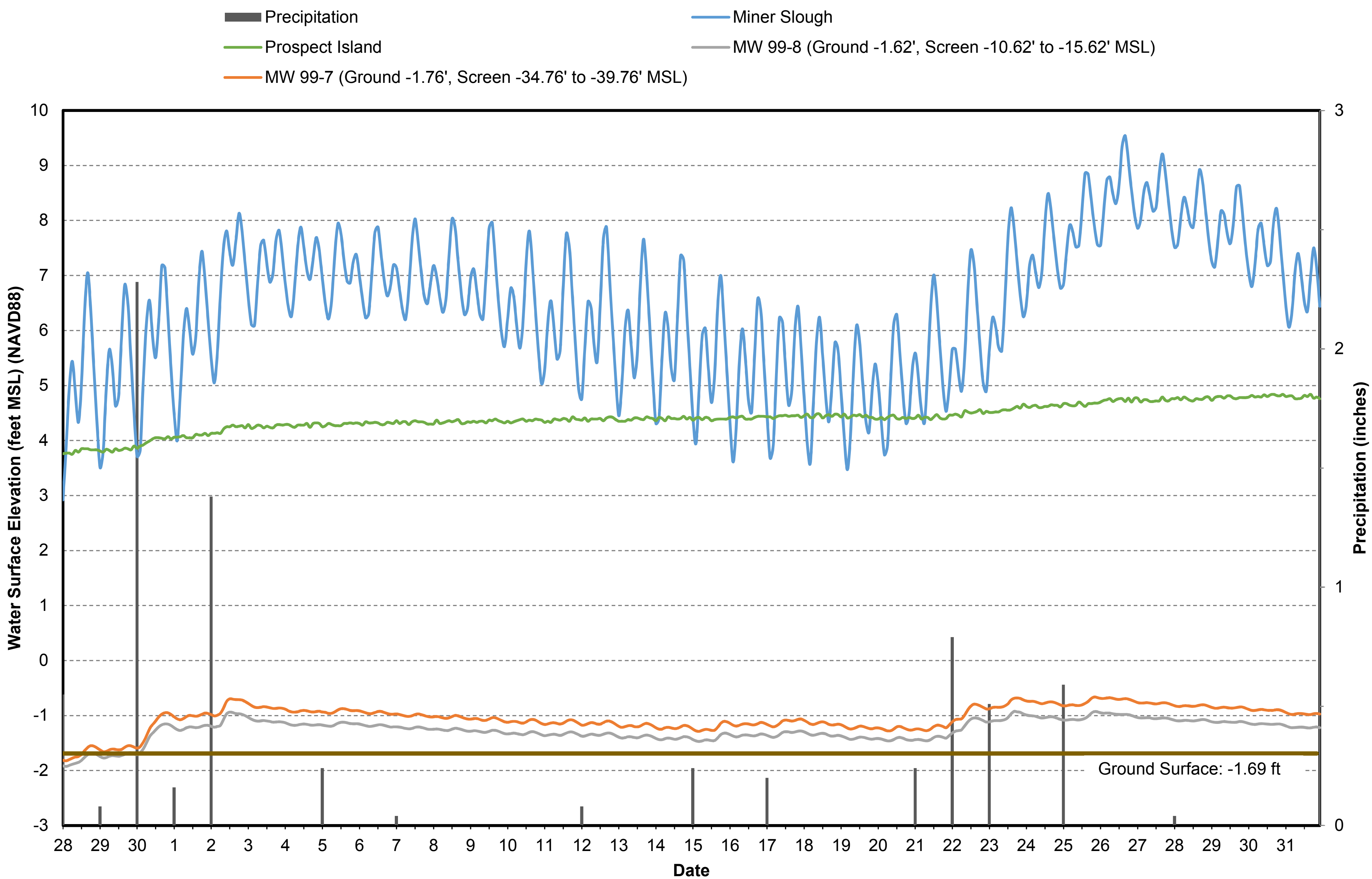


Figure 11-44

Hydrographs of Surface Water and Groundwater along North Transect with Precipitation at Georgiana Slough

Daily Mean Water Levels, Daily Precipitation - December 21, 2011 to October 1, 2013

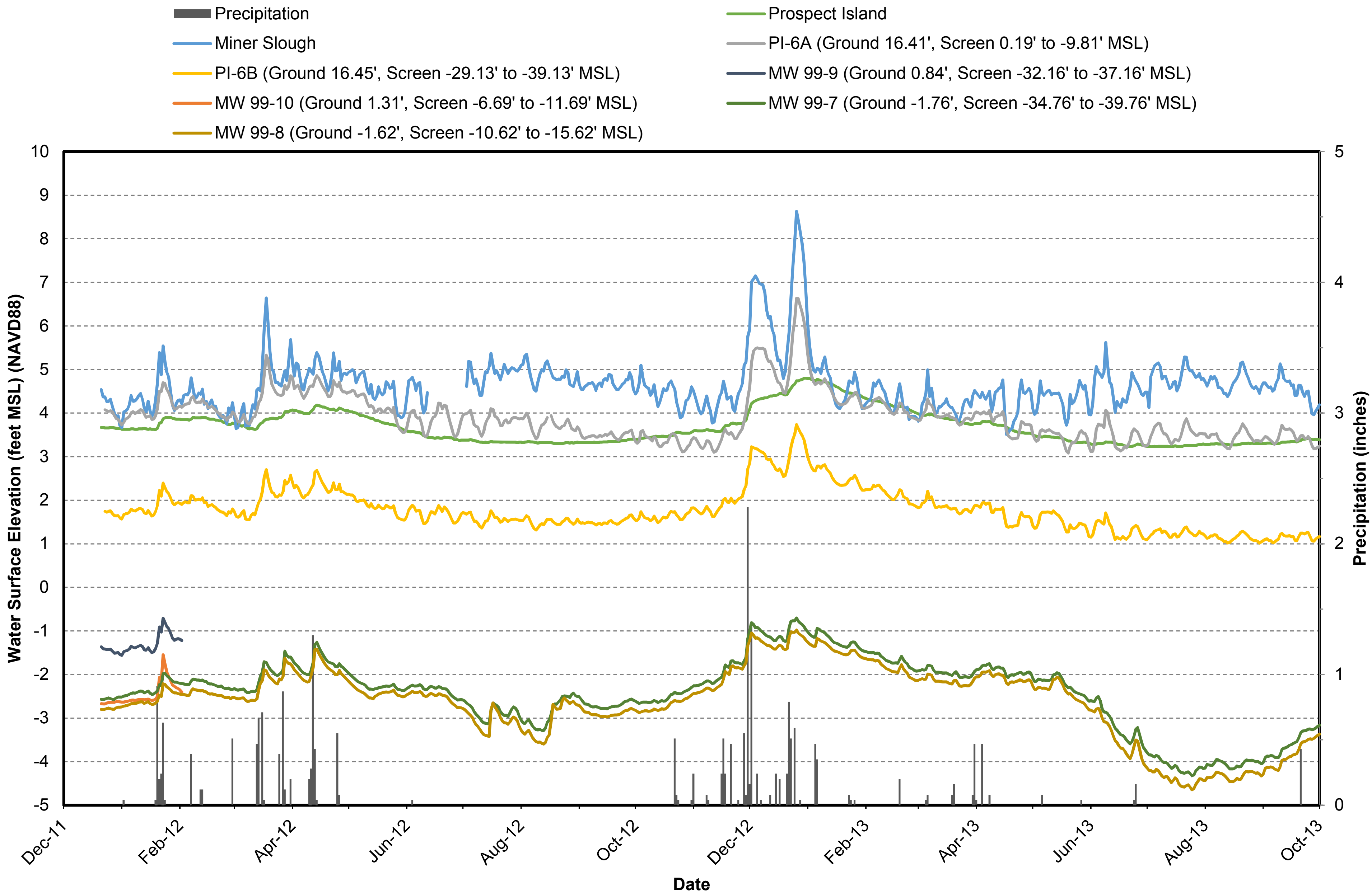


Figure 11-45

Hydrographs of Surface Water and Groundwater along Middle Transect with Precipitation at Georgiana Slough

Daily Mean Water Levels, Daily Precipitation - December 21, 2011 to October 1, 2013

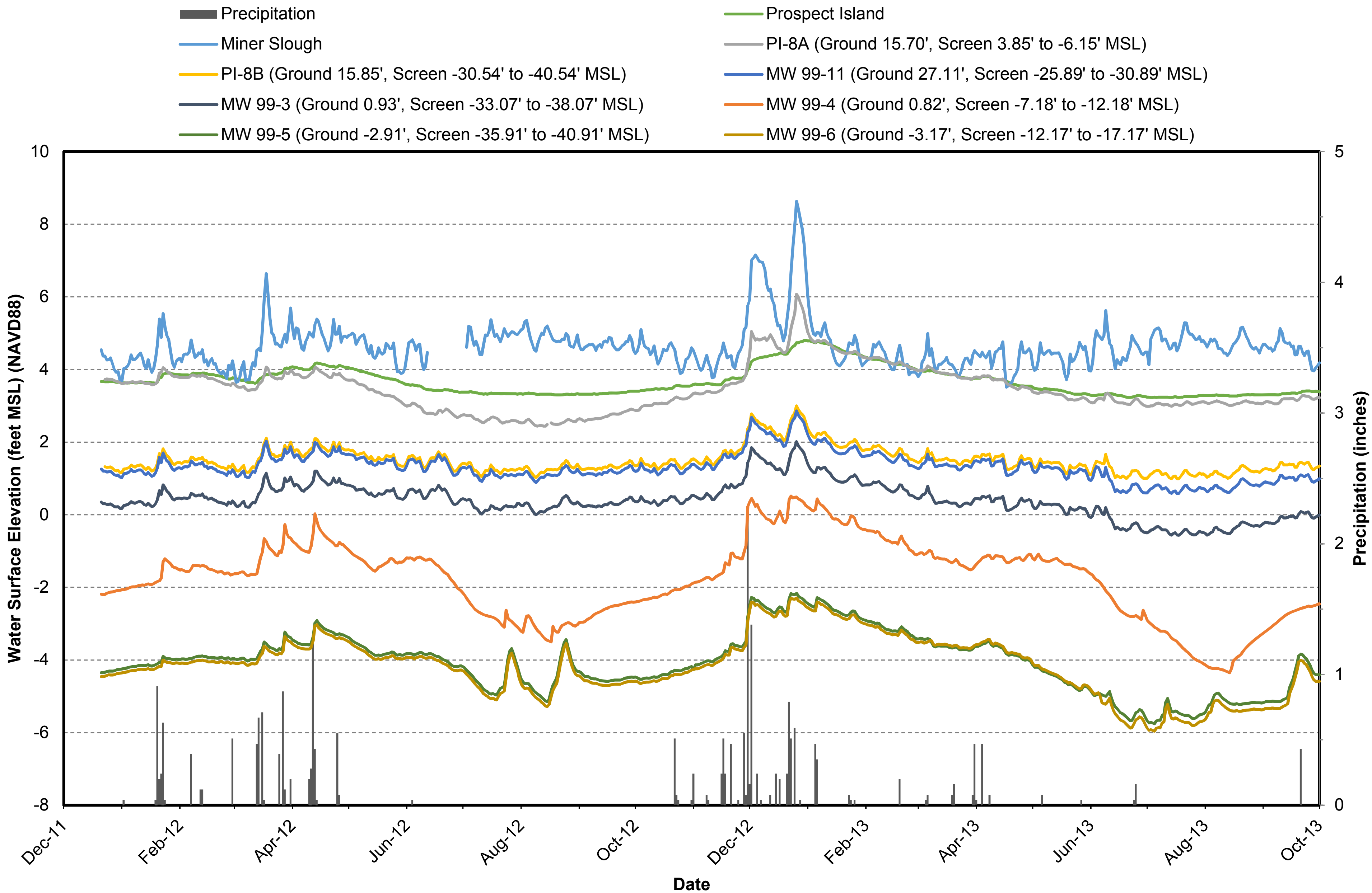


Figure 11-46

Hydrographs of Surface Water and Groundwater along South Transect with Precipitation at Georgiana Slough

Daily Mean Water Levels, Daily Precipitation - December 21, 2011 to October 1, 2013

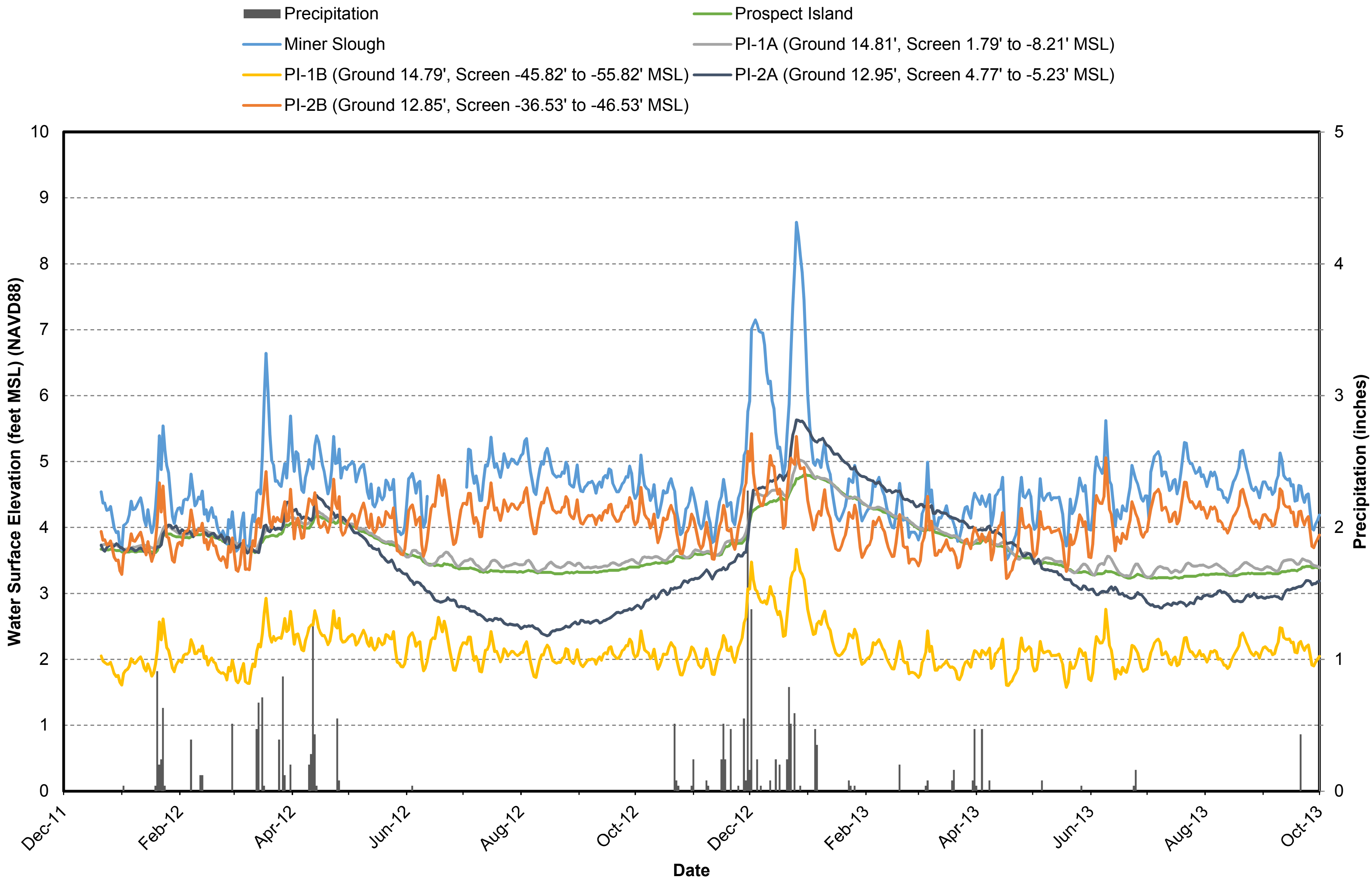
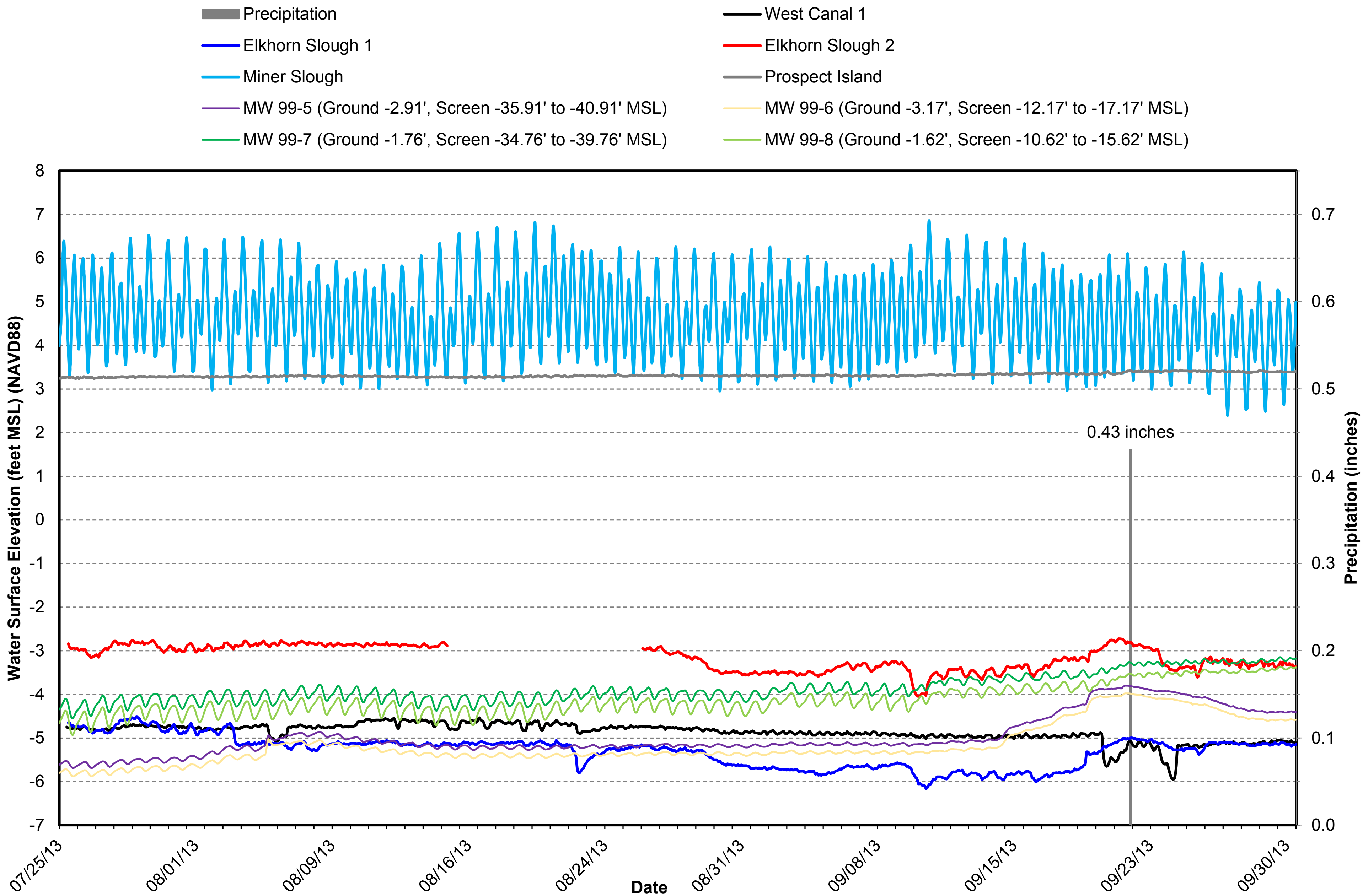
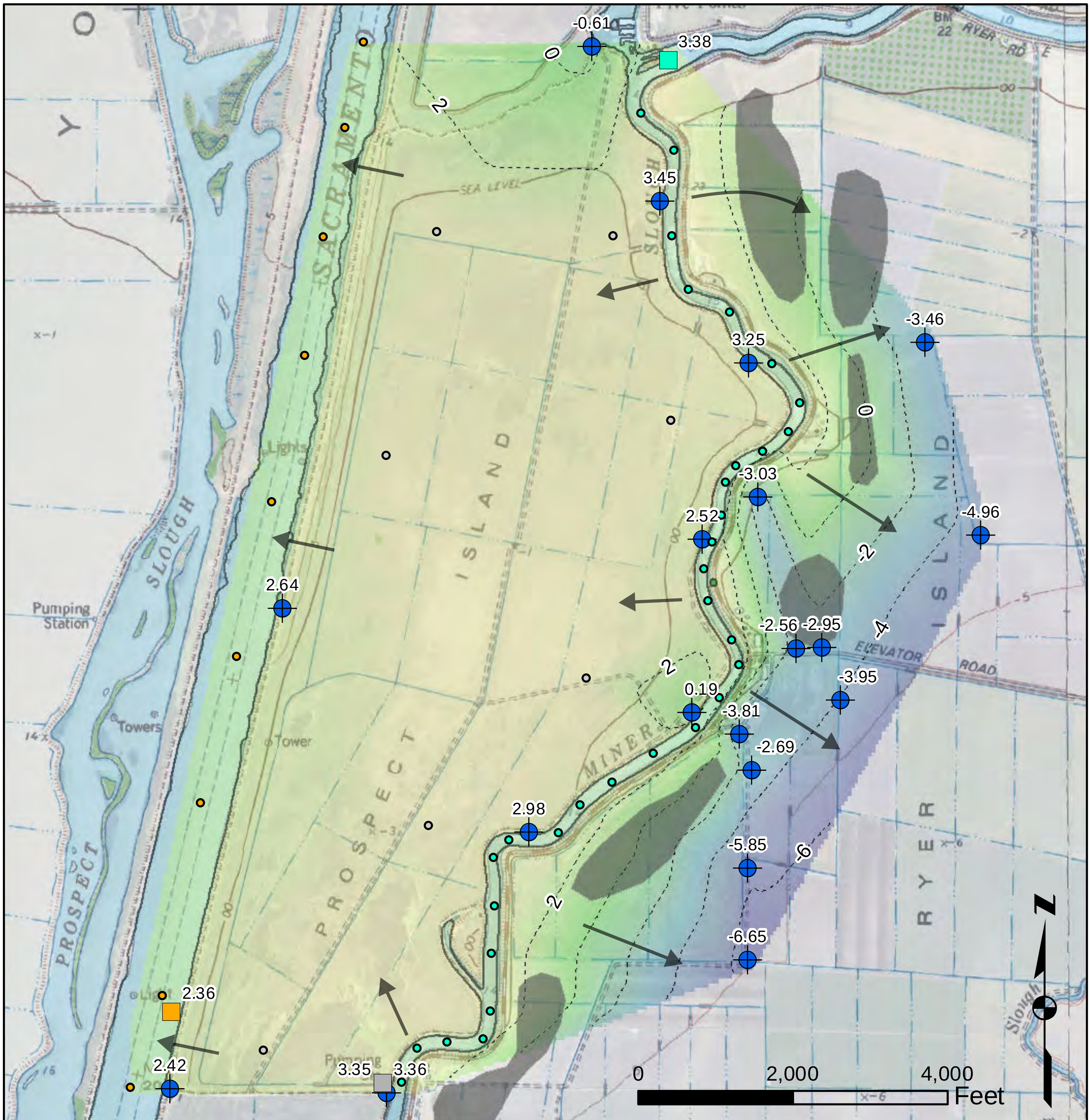


Figure 11-47

Hydrographs of Miner Slough Stage, Prospect Island Stage, Ryer Island Drainage Ditch Water Level, and Ryer Island Groundwater Levels with Precipitation at Georgiana Slough

July 25 to October 1, 2013





Groundwater Elevation from Well

Prospect Island Stage ○ inferred stage from gage

DWSC Stage ○ inferred stage from gage

Miner Slough Stage ○ inferred stage from gage

RD 501 Reported Seepage Areas

Groundwater Flow Direction

Potentiometric surface contour - Shows elevation of potentiometric surface on 08/09/2012 in the SHALLOW aquifer, in feet NAVD88. Contour interval is 2 feet.

Potentiometric surface (ft, NAVD88)

High : 3.4

Low : -6.6

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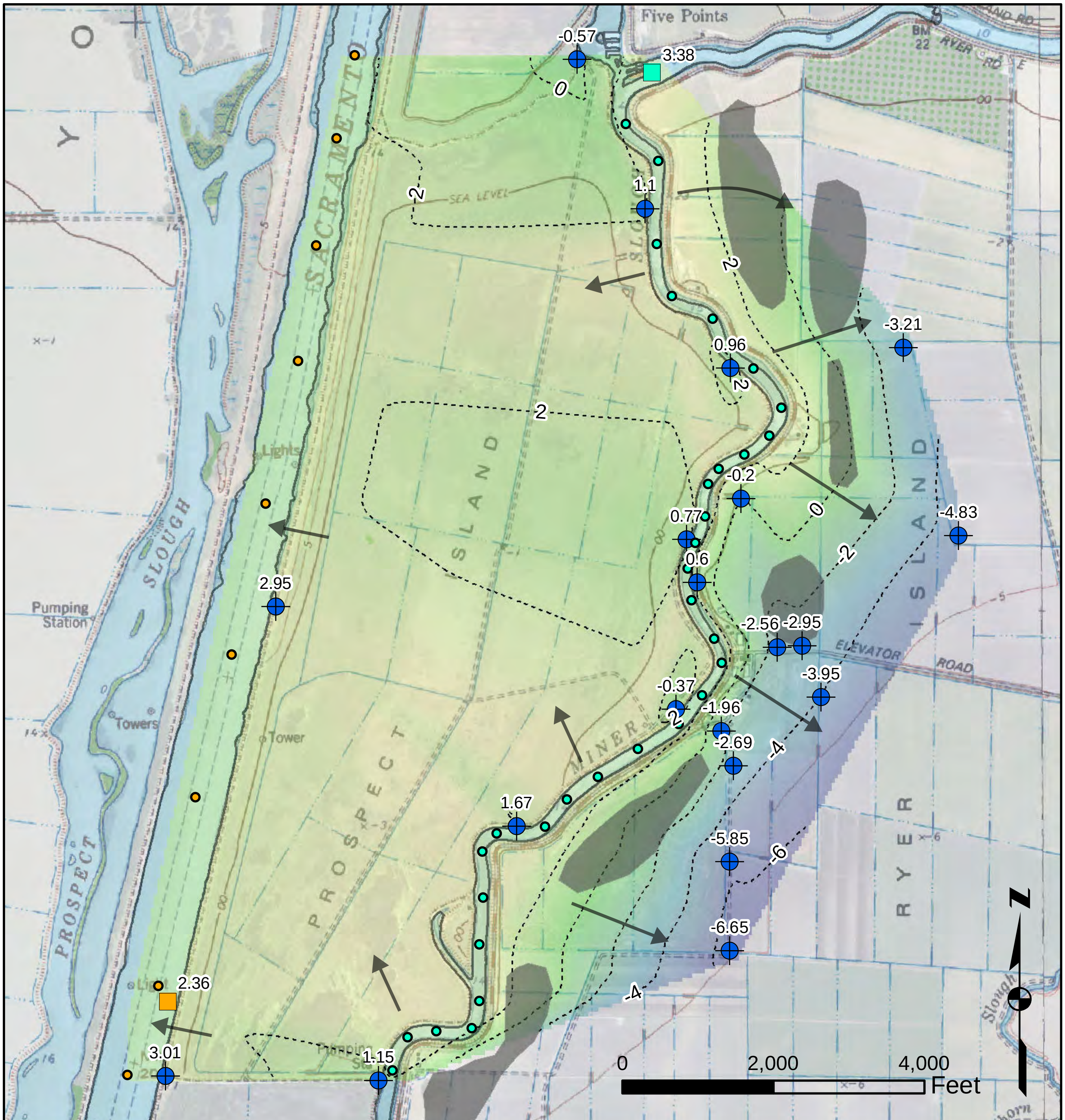
Geology and Groundwater Investigations Section

Groundwater Contour Map
Shallow Aquifer (Upper Clay HU)
08/09/2012

Figure 11-48



- Groundwater Elevation from Well
- Miner Slough Stage — inferred stage from gage
- DWSC Stage — inferred stage from gage
- RD 501 Reported Seepage Areas
- Groundwater Flow Direction

Potentiometric surface contour - Shows elevation of potentiometric surface on 08/09/2012 in the MAIN SAND aquifer, in feet NAVD88. Contour interval is 2 feet.

Potentiometric surface (ft, NAVD88)

High : 3.4

Low : -6.6

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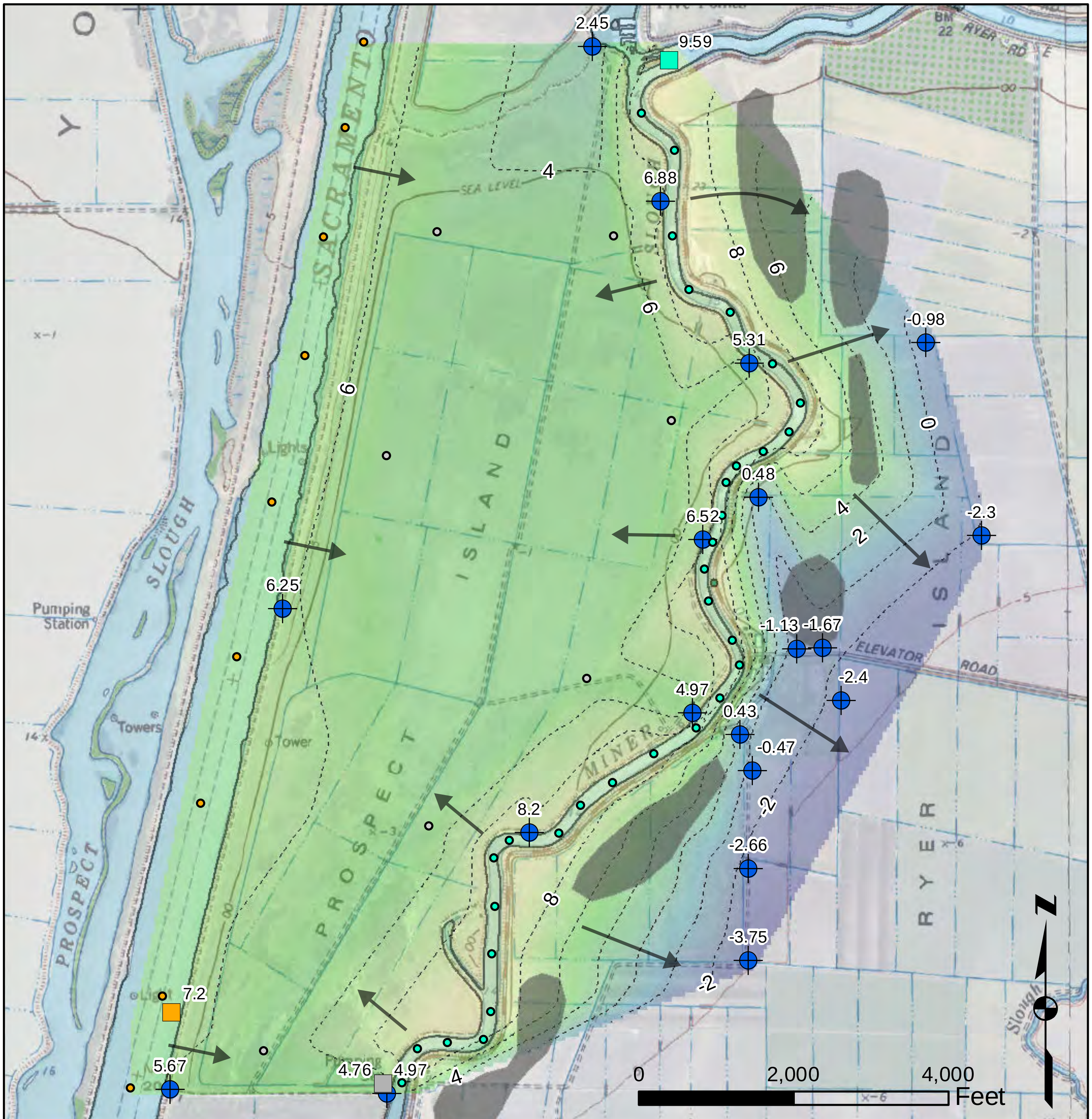
Groundwater Contour Map
Main Sand Aquifer (Main Sand HU)
08/09/2012

Figure 11-49



Groundwater Elevation from Well

Prospect Island Stage — inferred stage from gage

DWSC Stage — inferred stage from gage

Miner Slough Stage — inferred stage from gage

RD 501 Reported Seepage Areas

Groundwater Flow Direction

Potentiometric surface contour - Shows elevation of potentiometric surface on 12/26/2012 in the SHALLOW aquifer, in feet NAVD88. Contour interval is 2 feet.

Potentiometric surface (ft, NAVD88)

High : 9.6

Low : -3.7

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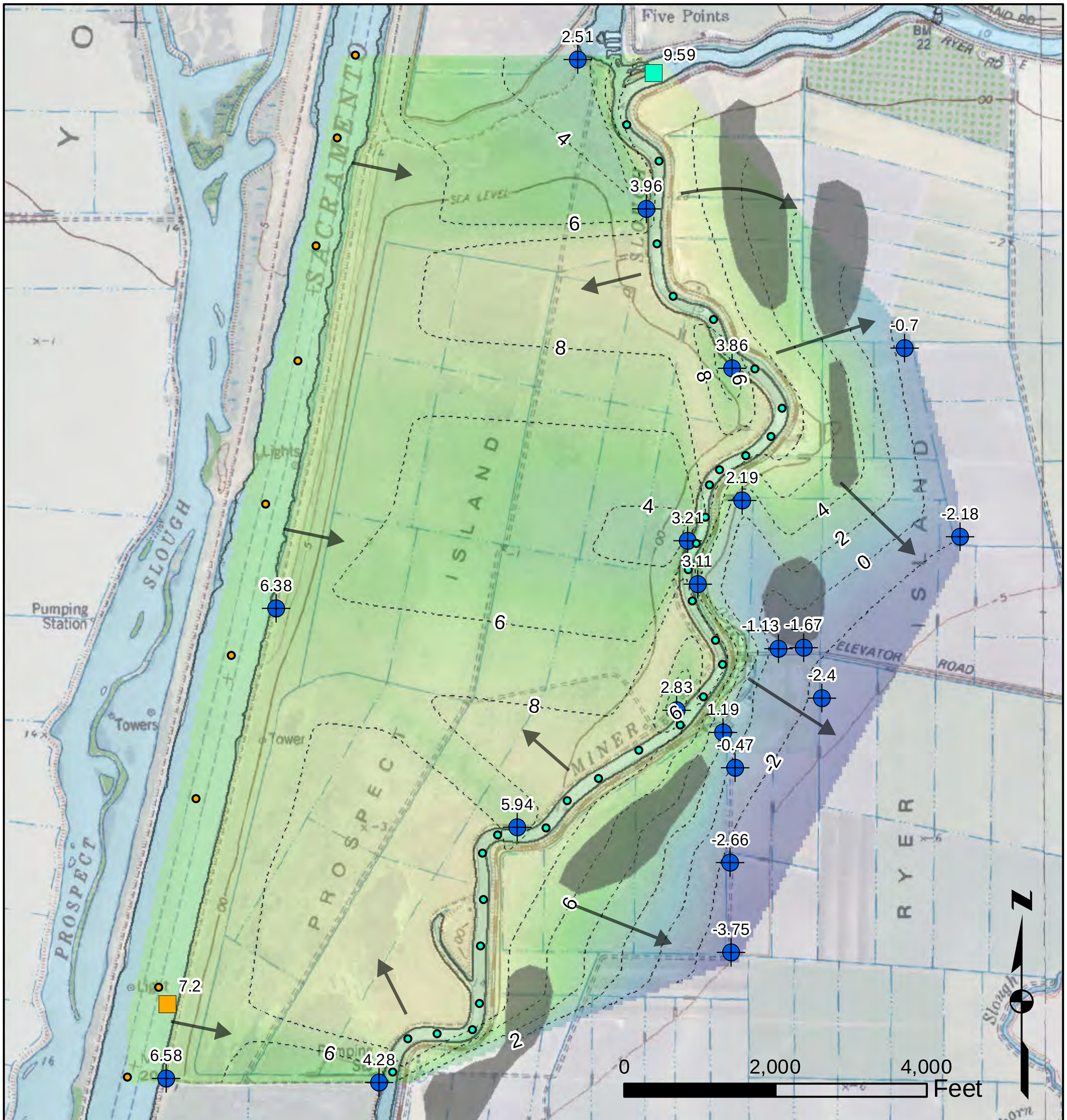
Groundwater Contour Map
Shallow Aquifer (Upper Clay HU)
12/26/2012

Figure 11-50



Groundwater Elevation from Well

Miner Slough Stage · inferred stage from gage

DWSC Stage · inferred stage from gage

RD 501 Reported Seepage Areas

Groundwater Flow Direction

Potentiometric surface contour - Shows elevation of potentiometric surface on 12/26/2012 in the MAIN SAND aquifer, in feet NAVD88. Contour interval is 2 feet.

Potentiometric surface (ft, NAVD88)

High : 9.6

Low : -3.7

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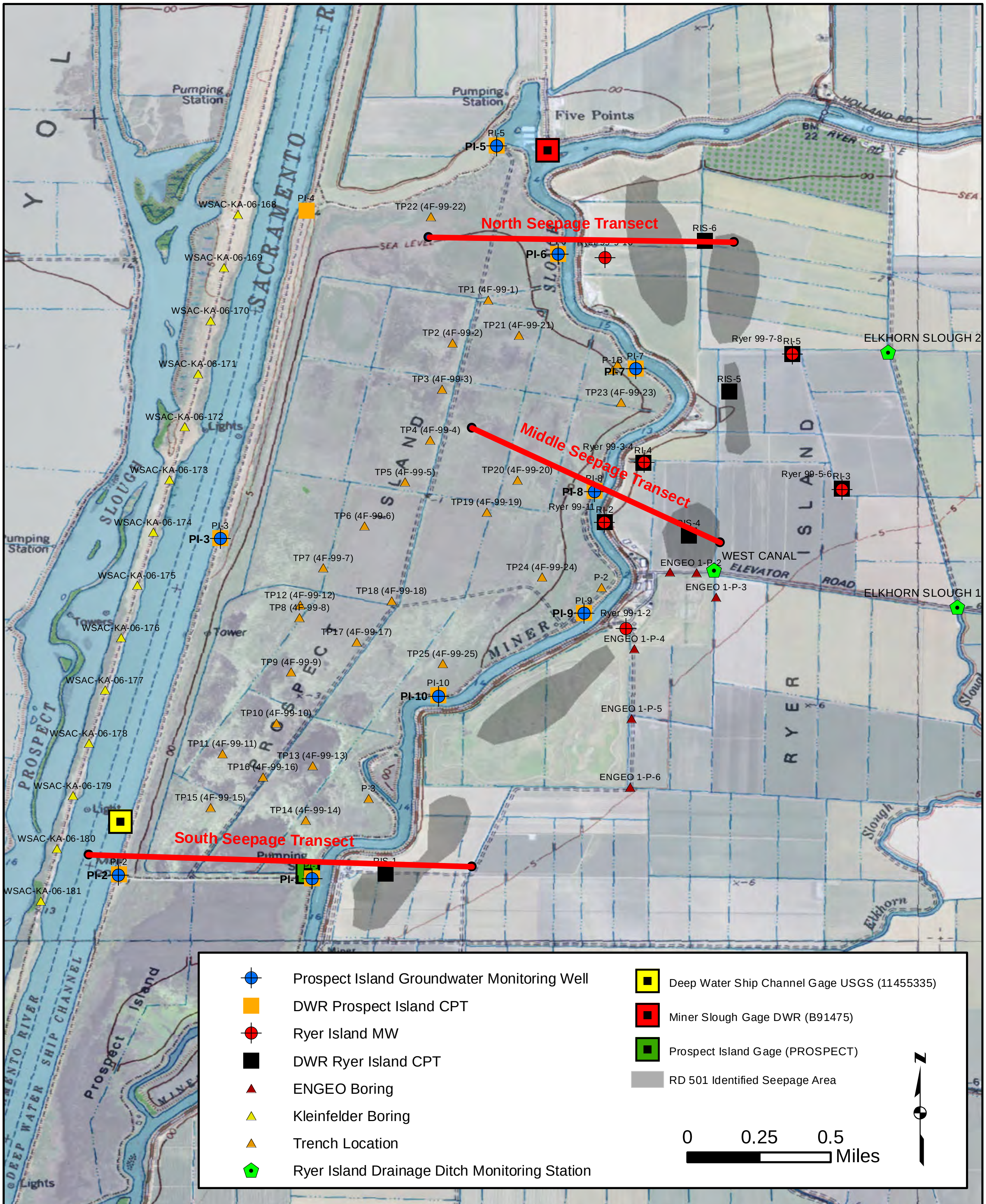
Groundwater Contour Map
Main Sand Aquifer (Main Sand HU)
12/26/2012

Figure 11-51



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Seepage Transect Locations

Figure 12-1

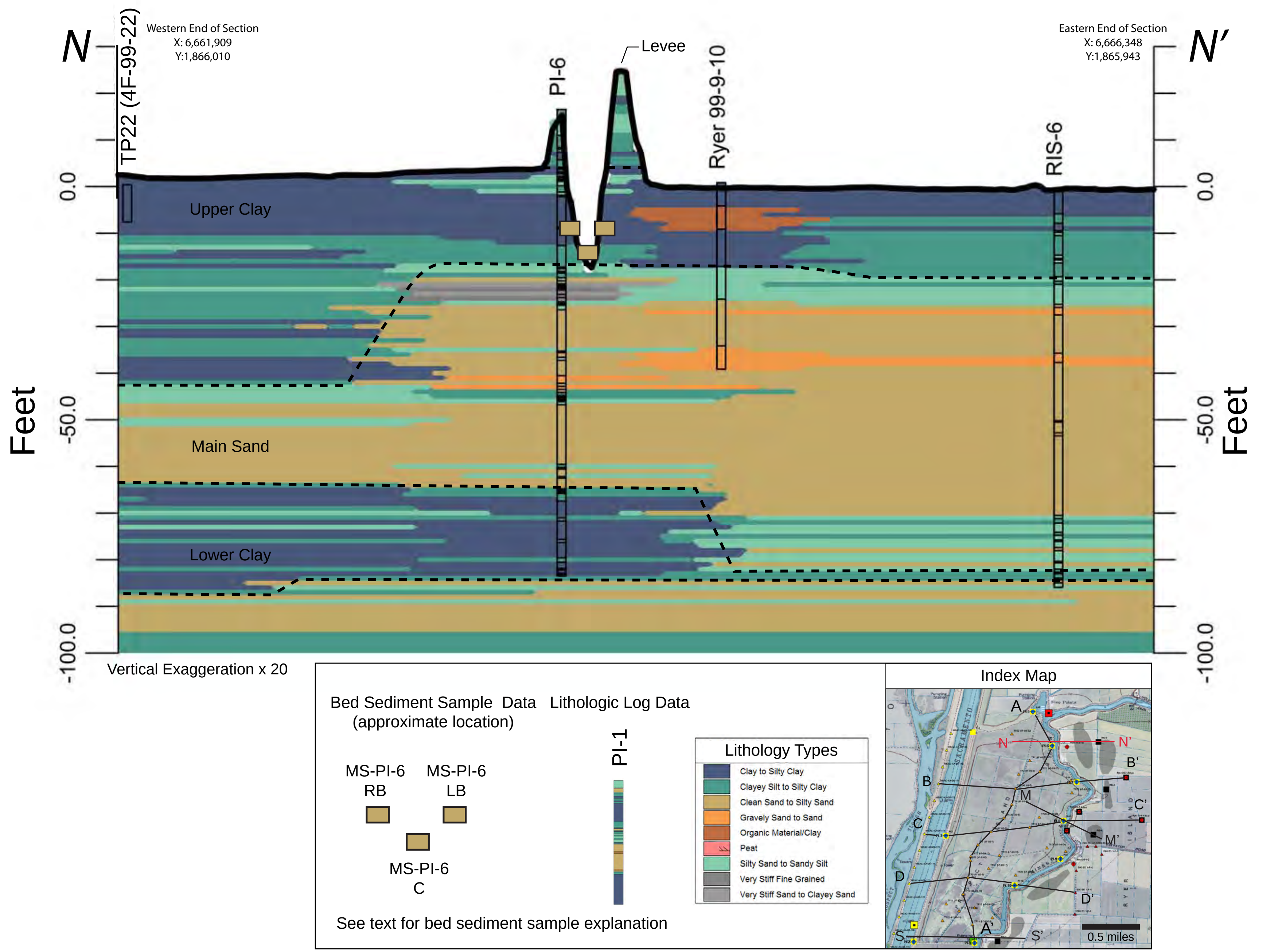


Figure 12-2. North Seepage Summary Section N - N’. 3D lithology and hydrogeologic units results. Lithologic logs within 500 feet of the section line are shown. Log data projected onto the section may not exactly match the land surface elevation along the line of section.

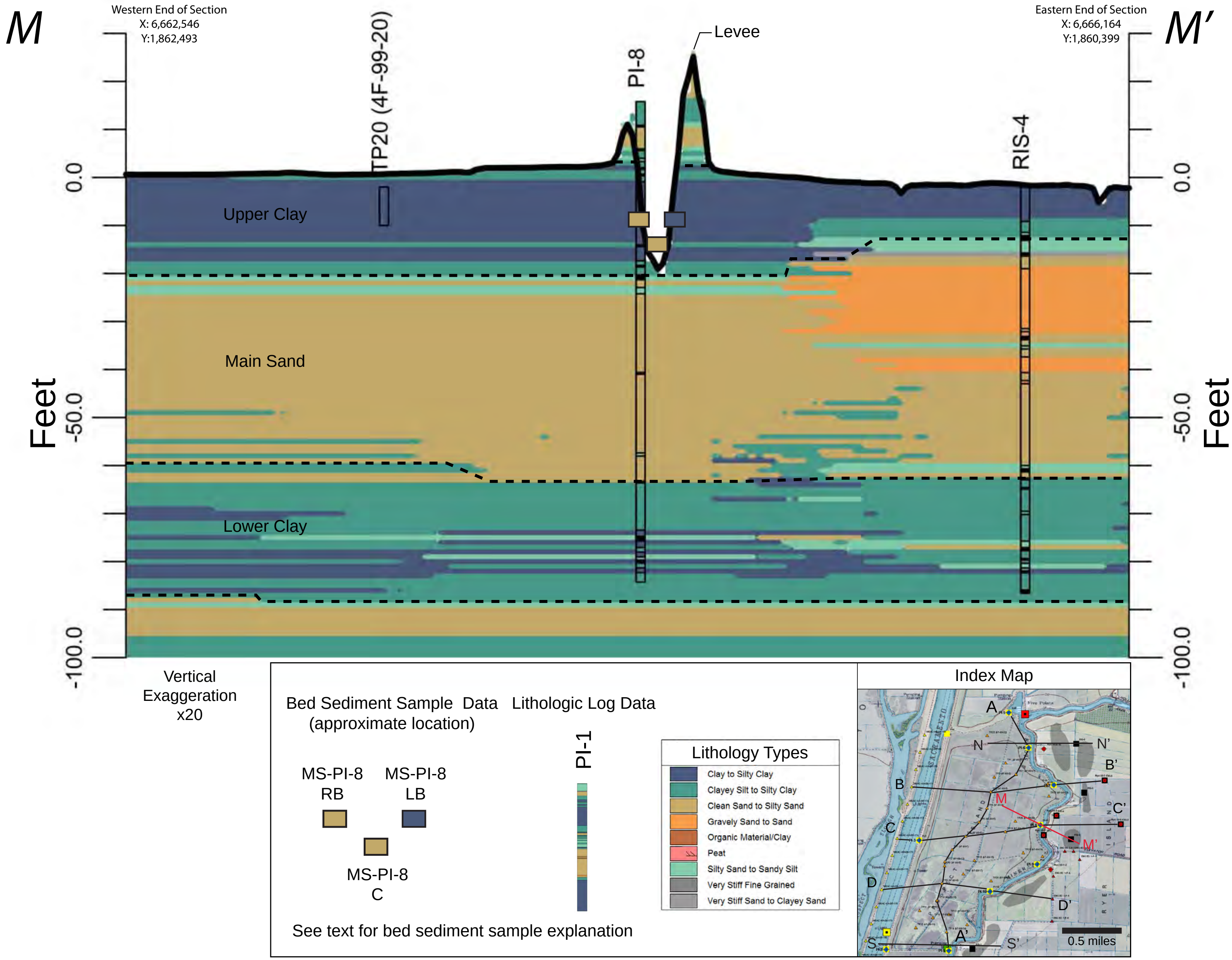


Figure 12-3. Middle Seepage Summary Section M - M'. 3D lithology and hydrogeologic units results. Lithologic logs within 500 feet of the section line are shown. Log data projected onto the section may not exactly match the land surface elevation along the line of section.

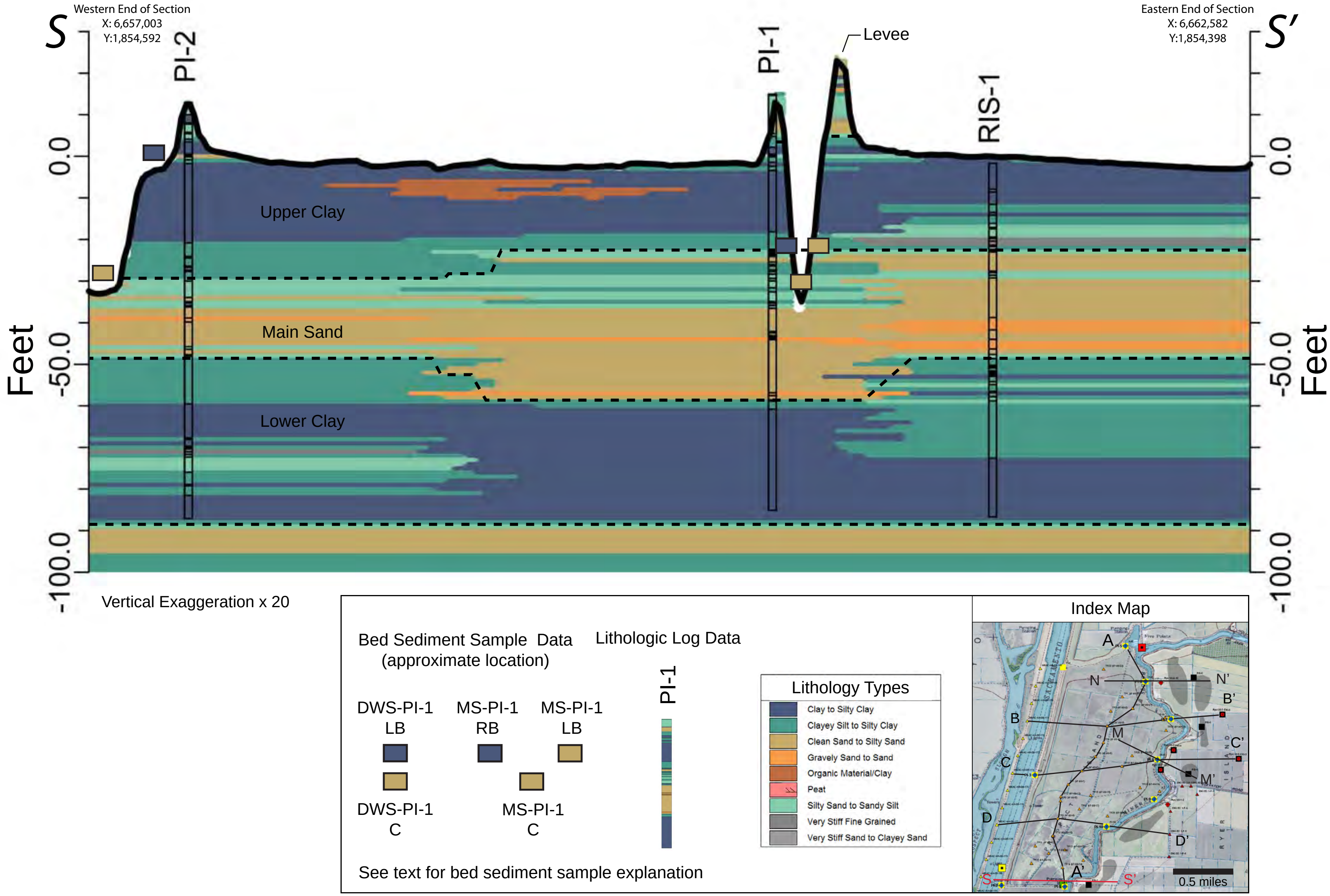
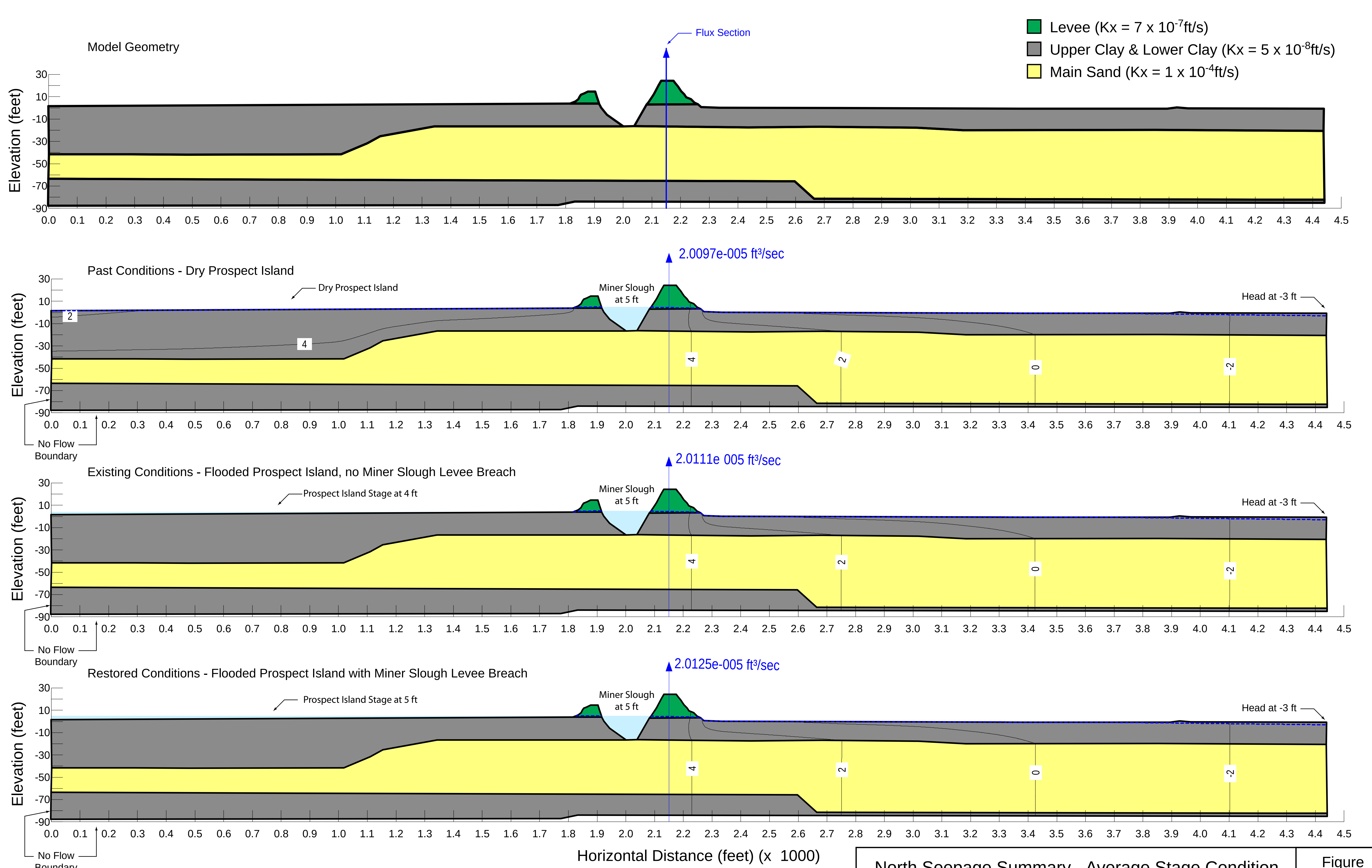
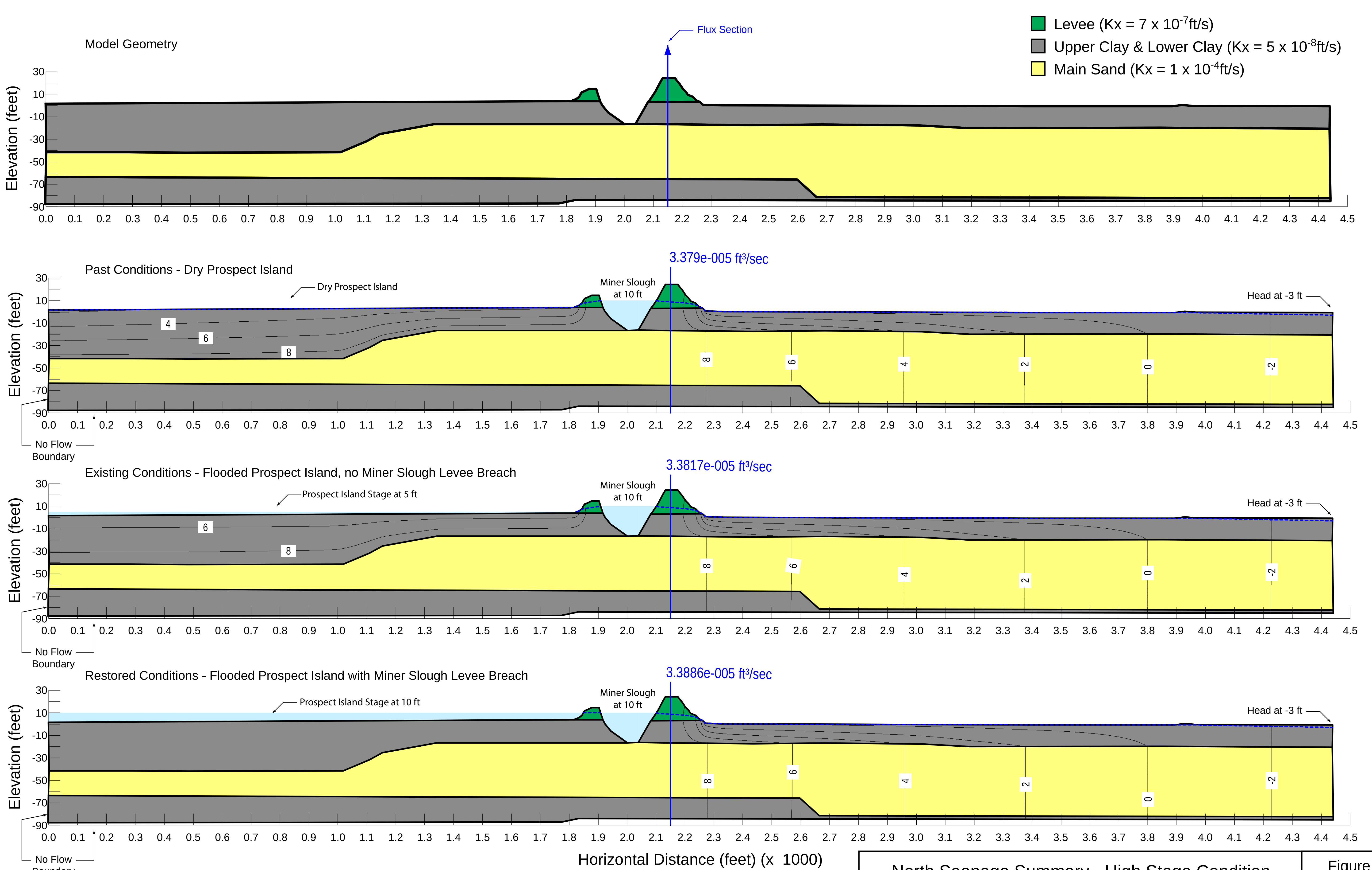


Figure 12-4. South Seepage Summary Section S - S'. 3D lithology and hydrogeologic units results. Lithologic logs within 250 feet of the section line are shown. Log data projected onto the section may not exactly match the land surface elevation along the line of section.



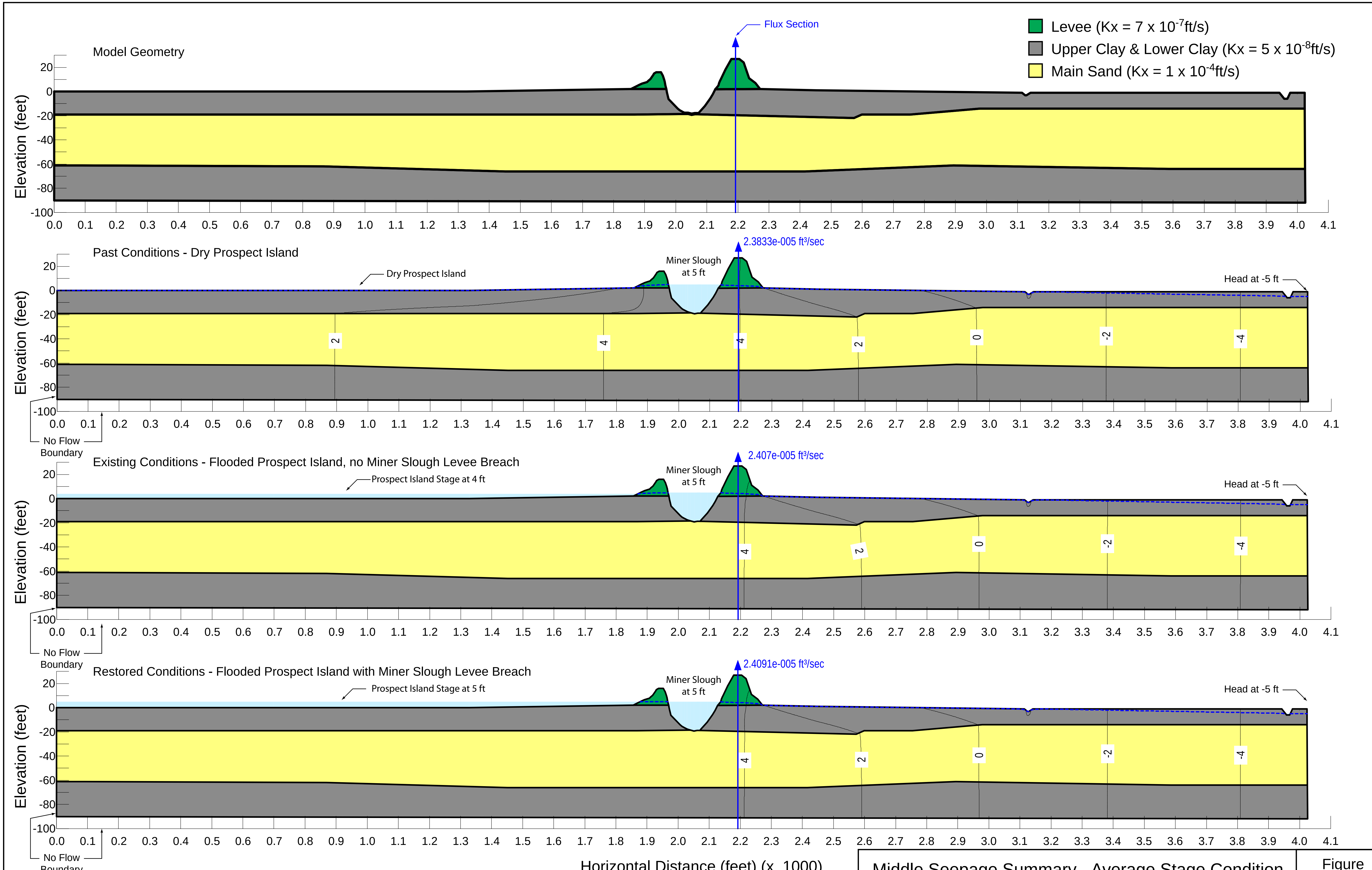
North Seepage Summary - Average Stage Condition

Figure 12-5



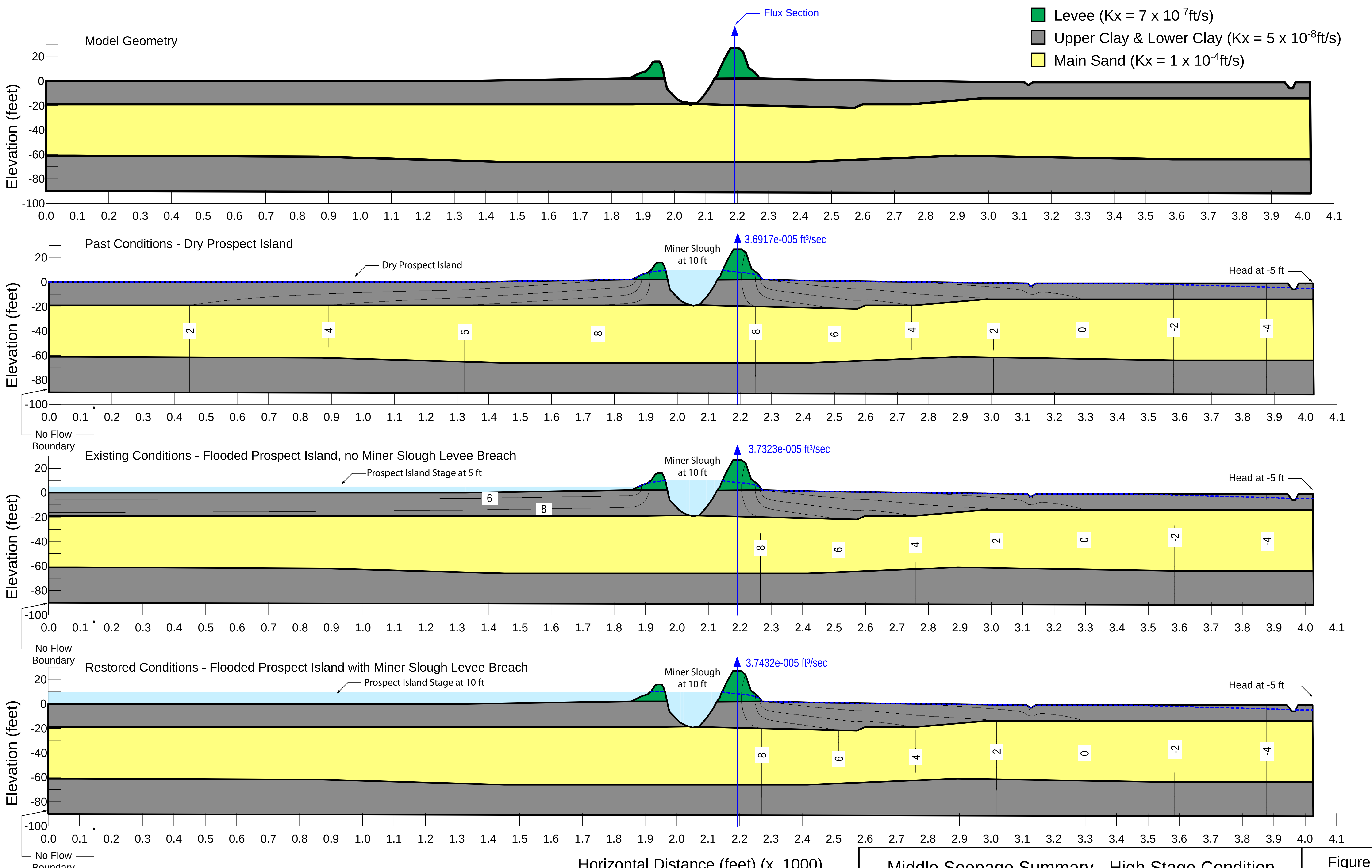
North Seepage Summary - High Stage Condition

Figure 12-6



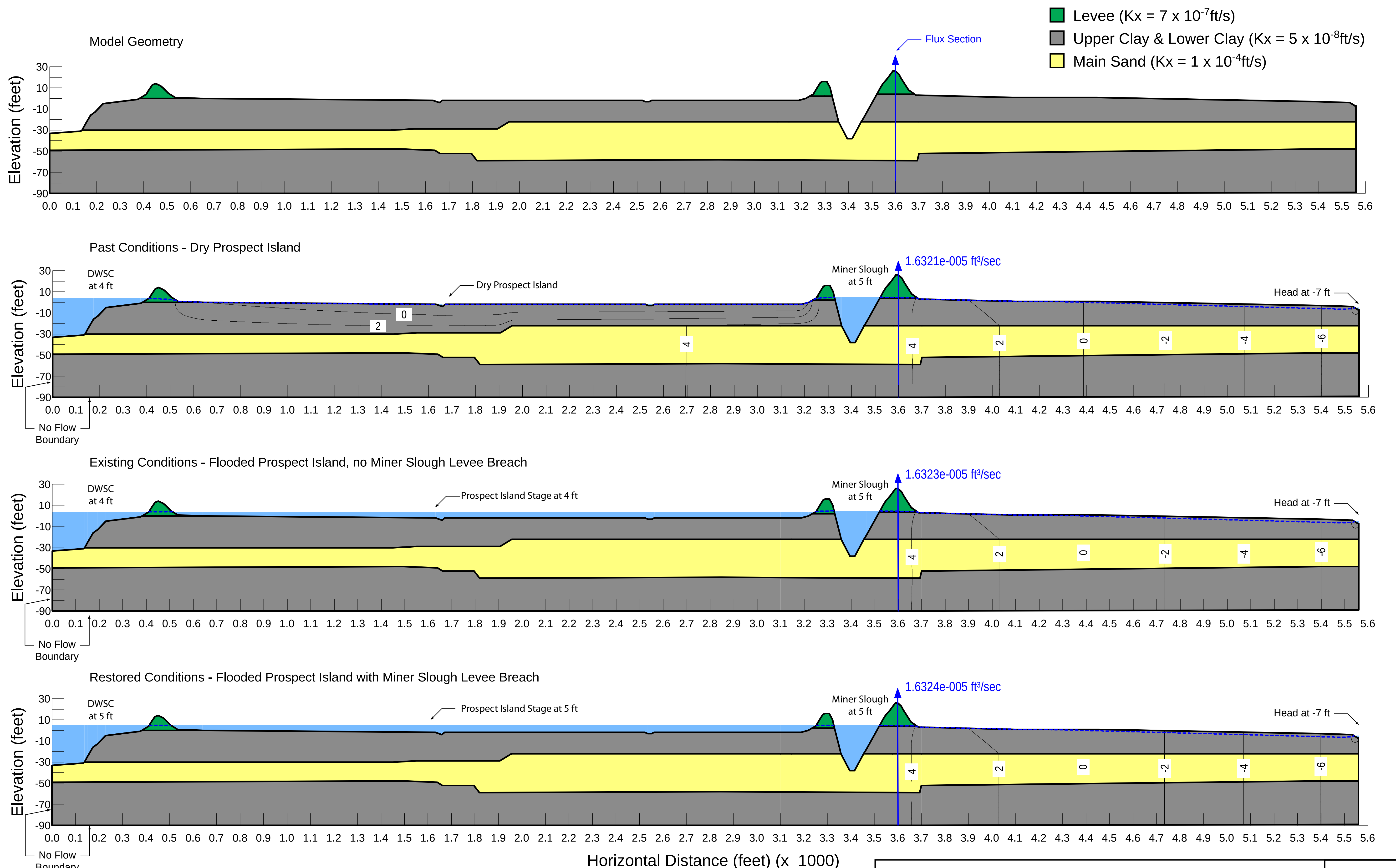
Middle Seepage Summary - Average Stage Condition

Figure 12-7



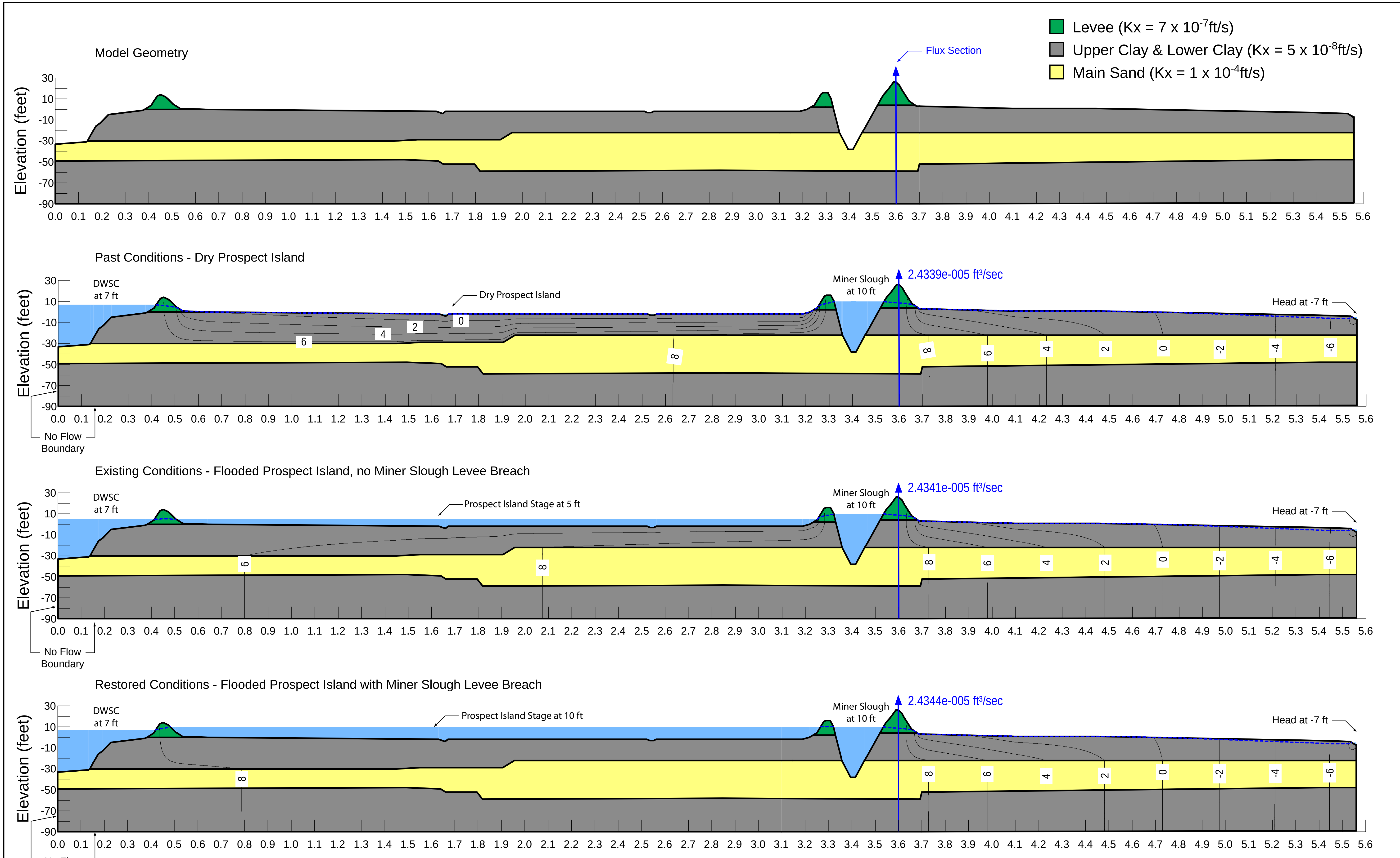
Middle Seepage Summary - High Stage Condition

Figure 12-8



South Seepage Summary - Average Stage Condition

Figure 12-9



South Seepage Summary - High Stage Condition

Figure 12-10

Tables

Table 5-1. Compilation of Prospect Island Flooding, Ownership, and Legal Information

Year	Island flooding reported				Ownership (DWR, 2012)	Ownership and Legal Information
	URS, 2009	Hopf, 2011				
1962		x	10/15/62		Sacramento-Yolo Port District (SYPD)	
1963	x	x	2/1/63		SYPD/Sakata Bros Inc	Sakata Bros Inc acquired Prospect Island on 5/3/63
1964					Sakata Bros Inc (SBI)	
1965					SBI	
1966					SBI	
1967					SBI	
1968					SBI	
1969					SBI	
1970					SBI	
1971					SBI	
1972					SBI	
1973					SBI	
1974					SBI	
1975					SBI	
1976					SBI	
1977					SBI	
1978					SBI	
1979					SBI	
1980	x	x	2/12/80		SBI	
1981	x	x	12/23/81		SBI	
1982	x				SBI	
1983	x	x	1/30/83	3/1/83	SBI	
1984					SBI	
1985					SBI	
1986	x	x	2/19/86		SBI	
1987					SBI	
1988					SBI	
1989					SBI	
1990					SBI	
1991					SBI	
1992					SBI	

Table 5-1. Compilation of Prospect Island Flooding, Ownership, and Legal Information

Year	Island flooding reported				Ownership (DWR, 2012)	Ownership and Legal Information
	URS, 2009	Hopf, 2011				
1993					SBI	
1994					SBI	
1995	x	x		3/14/95*	SBI/USBR	The US government acquired Prospect Island on January 3, 1995. Prospect flooded on March 14, 1995. **Slater Farms Inc.** (a Prospect Island lessee) filed a lawsuit against USBR for losses incurred for site preparation and lost profits for 1996 and 1997 (USBR decided to buy out the lease). USBR repaired the levee and pumped out the island in March-November 1996 and settled the lawsuit in August 1996. The lessee alleged that USBR should have repaired the levee breaches and reclaimed the land sooner so that a crop could have been planted in 1995. USBR paid nearly $400,000 in settlement for 1995 site preparation (herbicide application, grading) and 1996 and 1997 buy out of lease (profits they might have made had the lease not been bought out)(USACE, 2001)
1996					USBR	In 1996, **Islands, Inc.** filed a complaint against USBR for crop damage allegedly caused by subsurface movement of groundwater from Prospect Island to Ryer Island (Leagle.com, 2012) On August 26, 1996, **Sam Sakata Farms** filed a complaint for damages alleging that "hydrologic pressure" from flooded conditions on Prospect Island had resulted in flooding on Ryer Island (Todd, 1998)
1997	x	x	1/5/97		USBR	
1998					USBR	
1999					USBR	On September 3, 1999, **RD 501 and Islands, Inc.** filed a complaint against USACE and DWR claiming the Prospect Island Ecosystem Restoration Project environmental document was inadequate and the decision to leave Prospect Island in a submerged state has caused and continues to cause seepage under the soil on the immediately adjacent Ryer Island, specfically under land owned by Islands, Inc. and for which RD 501 has reclamation responsibility. This seepage prevents the overlying farmland from growing crops which it has historically grown and causes farm equipment to become mired in the saturated soil (RD 501/Islands, Inc., 1999). The **1996 Islands, Inc. complaint** was dismissed due to federal government immunity from suit under the Flood Control Act (Leagle.com, 2012)

Table 5-1. Compilation of Prospect Island Flooding, Ownership, and Legal Information

Year	Island flooding reported				Ownership (DWR, 2012)	Ownership and Legal Information
	URS, 2009	Hopf, 2011				
2000					USBR	
2001					USBR	
2002					USBR	
2003					USBR	
2004					USBR	
2005					USBR	
2006		x	1/1/06		USBR	
2007					USBR	
2008					USBR	
2009					USBR	
2010					USBR/DWR	DWR acquired Prospect Island on January 7, 2010
2011					DWR	
2012					DWR	
2013					DWR	

References:

DWR, 2012. Prospect Island Chain of Title prepared on December 11, 2012 by DWR Cadastral Unit.

Hopf, 2011. Levee Failures in the Sacramento-San Joaquin River Delta, PhD dissertation, Texas A&M, Appendix M.

Leagle.com, 2012, Summary of March 11, 1999 Islands, Inc. vs USBOR memorandum and order.

RD 501 and Islands, Inc., 1999. Complaint for Declatory and Injunctive Relief. September 3.

Todd, 1998. Preliminary Seepage Analysis, Prospect Island, California. Technical Memorandum. Todd Engineers. May.

URS, 2009. DRMS Phase 1 Risk Analysis Report - Final, Section 7 Flood Risk Analysis, Table 7-9a Islands/Tracts Flooded Since 1900.

USACE, 2001. Prospect Island Ecosystem Restoration Project Environmental Assessment/Initial Study. June.

* = Leagle.com summary of March 11, 1999 Islands Inc. vs USBOR memorandum and order

Table 8-1. Correlation Chart of Lithology Types, Geotechnical and Normalized Soil Behavior Type Data

Lithology Types used in 3D Model		Corresponding Geotechnical and Trench Log Soil Classifications		
SBTn Classification	SBTn Zone	USCS Symbol	Soil Type	Source
Peat	1	PT	Peat	USACE Trench Logs
Organic Material	2	OH	Organic Soil	USACE Trench Logs
		OH/CH	Organic clay and Fat Clay	USACE Trench Logs
Clay to Silty Clay	3	CH	Lean Clay and Fat Clay	USACE Trench Logs
		CH	Fat Clay	Geotechnical Boring Logs/USACE Trench Logs
		CH/CL	Borderline Fat clay and Lean Clay	USACE Trench Logs
		CL	Lean Clay	Geotechnical Boring Logs
		CL/CH	Borderline Lean Clay Fat Clay	USACE Trench Logs
Clayey Silt to Silty Clay	4	CH	Fat Clay with Sand	Geotechnical Boring Logs
		CH	Fat Clay with Gravel	Geotechnical Boring Logs
		CL	Lean Clay with Sand	Geotechnical Boring Logs/USACE Trench Logs
		CL	Lean Clay With Interbedded Silty Sand Layers	Geotechnical Boring Logs
		ML	Silt	Geotechnical Boring Logs
		ML	Elastic Silt	Geotechnical Boring Logs
		ML	Silt With Gravel	Geotechnical Boring Logs
		ML	Silt With Sand	Geotechnical Boring Logs
		ML/CL	Borderline Silty Lean Clay	USACE Trench Logs
Silty Sand to Sandy Silt	5	CH	Sandy Fat Clay With Gravel	Geotechnical Boring Logs
		CH	Sandy Fat Clay	Geotechnical Boring Logs
		CL	Sandy Lean Clay	Geotechnical Boring Logs/USACE Trench Logs
		CL	Lean Clay with Gravel	Geotechnical Boring Logs
		ML	Sandy Silt	Geotechnical Boring Logs/USACE Trench Logs
		ML	Sandy Silt With Gravel	Geotechnical Boring Logs
Clean Sand to Silty Sand	6	ML/SM	Sandy Silt/Silty Sand	Geotechnical Boring Logs
		SC	Clayey Sand	Geotechnical Boring Logs/USACE Trench Logs
		SC	Clayey Sand With Gravel	Geotechnical Boring Logs
		SC/CL	Clayey Sand/Lean Clay	Geotechnical Boring Logs
		SM	Silty Sand	Geotechnical Boring Logs/USACE Trench Logs
		SM	Silty Sand With Gravel	Geotechnical Boring Logs
		SP	Poorly Graded Sand	Geotechnical Boring Logs/USACE Trench Logs
		SP-SC	Poorly Graded Sand with Clay	Geotechnical Boring Logs

Table 8-1. Correlation Chart of Lithology Types, Geotechnical and Normalized Soil Behavior Type Data

Lithology Types used in 3D Model		Corresponding Geotechnical and Trench Log Soil Classifications		
SBTn Classification	SBTn Zone	USCS Symbol	Soil Type	Source
Clean Sand to Silty Sand	6	SP-SM	Poorly Graded Sand With Silt	Geotechnical Boring Logs
		SW	Well Graded Sand	Geotechnical Boring Logs
		SW-SM	Well Graded Sand With Silt and Gravel	Geotechnical Boring Logs
Gravely Sand to Sand	7	GP	Aggregate	Geotechnical Boring Logs
Very Stiff Sand to Clayey Sand	8	Only observed in SBTn data		
Very Stiff Fine Grained	9	Only observed in SBTn data		

Table 8-2. Bed Sediment Sample Summary

Sample ID	Time (PST)	Sample depth (ft-bws)	Easting	Northing	Field Description/Notes	Lab Description	Estimated K (cm/s)
DWS-PI-2-CL	1050	36.2	6656955.879	1854259.31	SAND		3E-04
DWS-PI-2-LB	1048	9.9	6657198.679	1854228.481	CLAY		2E-08
DWS-PI-2-RB	1055	6	6656672.235	1854327.481	SILTY SAND		9E-07
DWS-PI-3-CL	1107	36.8	6658435.447	1860463.637	SAND		2E-03
DWS-PI-3-LB	1101	9.7	6658669.007	1860461.995	SANDY CLAY - ORGANICS		5E-08
DWS-PI-3-RB	1114	4.5	6658172.329	1860542.877	SANDY CLAY		1E-07
DWS-PI-4-CL	1126	36	6659698.048	1866595.726	SAND	not tested	*
DWS-PI-4-LB	1123	8.6	6659897.364	1866558.851	SANDY CLAY		8E-08
DWS-PI-4-RB	1129	21	6659533.834	1866666.957	SILTY SAND		5E-07
MS-DS-1	846	25.2	6663979.079	1866140.394	CLAY	not tested	*
MS-DS-2	911	34.9	6664249.847	1864423.899	SAND	SP, non-plastic fines	6E-02
MS-DS-3	927	26.9	6665573.515	1862958.118	SAND	SP, non-plastic fines	5E-02
MS-DS-4	947	32.3	6664638.275	1859433.374	CLAY	not tested	*
MS-DS-5	1019	42.7	6661650.351	1857340.987	SANDY CLAY		5E-09
MS-DS-6	1025	38.4	6660442.151	1854489.594	SAND	SP, non-plastic fines	6E-02
MS-PI-1-CL	1032	21.1	6660387.553	1854135.688	SAND	SP, non-plastic fines	2E-02
MS-PI-1-LB	1029	16.8	6660437.212	1854151.001	SAND	SP, non-plastic fines	2E-02
MS-PI-1-RB	1035	18.8	6660335.565	1854146.015	CLAY	not tested	*
MS-PI-6-CL	859	14.2	6663902.601	1865697.927	SAND	SP, non-plastic fines	6E-02
MS-PI-6-LB	905	16.7	6663956.082	1865697.352	SAND	SP, non-plastic fines	6E-02
MS-PI-6-RB	905	16.7	6663847.848	1865699.213	SAND	SP, non-plastic fines	3E-02
MS-PI-7-CL	919	22.4	6665016.883	1863681.383	SAND	SP, non-plastic fines	2E-02
MS-PI-7-LB	917	15.8	6665046.212	1863721.531	SAND	SP, non-plastic fines	5E-02
MS-PI-7-RB	922	13.6	6664986.024	1863653.928	CLAY	not tested	*
MS-PI-8-CL	934	22.1	6664409.221	1861274.231	SAND	SP, non-plastic fines	8E-02
MS-PI-8-LB	932	23.5	6664450.431	1861254.83	CLAY	not tested	*
MS-PI-8-RB	938	15.3	6664382.752	1861299.87	SILTY SAND		1E-06
MS-PI-9-CL	954	17.3	6664295.045	1858989.517	SAND	SP, non-plastic fines	2E-02
MS-PI-9-LB	952	17.9	6664328.467	1858968.535	SAND	SP, non-plastic fines	8E-02
MS-PI-9-RB	956	15	6664258.542	1859026.812	SAND AND GRAVEL		3E-03

Table 8-2. Bed Sediment Sample Summary

Sample ID	Time (PST)	Sample depth (ft-bws)	Easting	Northing	Field Description/Notes	Lab Description	Estimated K (cm/s)
MS-PI-10-CL	1007	23.3	6662071.94	1857423.725	CLAY	not tested	*
MS-PI-10-LB	1002	22.3	6662049.165	1857376.95	NO SAMPLE - HARD BOTTOM?	No sample collected	**
MS-PI-10-RB	1011	13.8	6662075.062	1857471.883	SAND	SP, non-plastic fines	3E-02

Notes:
Bed sediment samples collected on 2-14-13 using a flat-bottom work boat with a hand-line bed material sampler (US BMH-60)
PST = Pacific Standard Time
ft-bws = feet below water surface
Easting and Northing coordinates are in NAD 1983, State Plane California II, FIPS 0402, US Feet
* = K could not be estimated empirically since there was insufficient material for grain size and hydrometer analysis
** = K could not be estimated since sample collection at this location was unsuccessful
Estimated K for bed sediment samples taken from Table 10.5 - Hydraulic Conductivity (K) Estimates from Grain Size Analysis using SizePerm

Table 8-3. Thickness of Hydrogeologic Units

Hydrogeologic Unit	Thickness (feet)		
	Minimum	Mean	Maximum
Levee			
Prospect Island	N/A	14	N/A
Ryer Island	N/A	25	N/A
Upper Clay			
Prospect Island	17	25	55
Ryer Island	7	16	47
Main Sand			
Prospect Island	8	35	49
Ryer Island	21	38	67

N/A - The Levee HU was only delineated on seepage transects

Table 10-1. Hydraulic Conductivity Estimated from Soil Behavior Type (K_{sbt})

CPT Sounding	PI-1	PI-2	PI-3	PI-4	PI-5	PI-6	PI-7	PI-8	PI-9	PI-10	
Depth Interval (feet)	5-13	5-13	5-10	5-6	5-12	5-13	5-16	5-14	5-14	5-11	
Hydrogeologic Unit	Levee	Levee	Levee	Levee	Levee	Levee	Levee	Levee	Levee	Levee	Total sample size
sample size (n)	49	49	30	6	43	49	67	55	55	37	440
K_{sbt} (cm/s)											
min	9E-07	2E-07	2E-06	3E-06	3E-06	3E-07	6E-07	6E-07	4E-07	3E-08	
max	1E-03	3E-04	2E-03	8E-06	2E-04	2E-05	2E-03	2E-03	2E-03	3E-03	PI Levee GM
geomean (GM)	3E-05	1E-05	2E-05	5E-06	9E-06	2E-06	2E-05	5E-05	9E-05	1E-04	2E-05

CPT Sounding	PI-1	PI-2	PI-3	PI-4	PI-5	PI-6	PI-7	PI-8	PI-9	PI-10	
Depth Interval (feet)	13-39	13-43	10-36	6-65	12-61	13-36	16-35	14-37	14-35	11-39	
Hydrogeologic Unit	Upper Clay	U Clay	U Clay	U Clay	U Clay	U Clay	U Clay	U Clay	U Clay	U Clay	Total sample size
sample size (n)	158	183	159	366	298	140	116	140	128	170	1858
K_{sbt} (cm/s)											
min	9E-08	6E-08	9E-08	3E-07	9E-08	9E-08	6E-08	1E-07	4E-08	2E-08	
max	5E-04	9E-05	1E-05	4E-04	8E-05	4E-05	2E-04	3E-04	7E-05	3E-03	PI U Clay GM
geomean (GM)	8E-07	6E-07	7E-07	4E-06	1E-06	2E-06	6E-07	1E-06	4E-07	4E-06	1E-06

Table 10-1. Hydraulic Conductivity Estimated from Soil Behavior Type (K_{sbt})

CPT Sounding	PI-1	PI-2	PI-3	PI-4	PI-5	PI-6	PI-7	PI-8	PI-9	PI-10	
Depth Interval (feet)	39-74	43-61	36-72	65-72	61-81	36-82	35-75	37-79	35-78	39-69	
Hydrogeologic Unit	Main Sand	M Sand	M Sand	M Sand	M Sand	M Sand	M Sand	M Sand	M Sand	M Sand	Total sample size
sample size (n)	206	103	209	42	122	265	250	245	259	183	1884
K_{sbt} (cm/s)											
min	2E-06	8E-06	2E-06	8E-06	4E-06	2E-06	7E-07	6E-05	6E-07	4E-06	
max	6E-01	3E-01	2E-01	2E-02	1E-02	5E-01	3E-01	2E-01	4E-01	2E-01	PI M Sand GM
geomean (GM)	3E-03	3E-03	6E-03	3E-03	1E-03	3E-03	7E-03	1E-02	5E-03	4E-03	4E-03

CPT Sounding	RI-2	RI-2	RI-3	RI-4	RI-5	RIS-1	RIS-4	RIS-5	RIS-6		
Depth Interval (feet)	5-25	25-49	5-8	5-14	5-20	5-14	5-12	5-17	5-19		
Hydrogeologic Unit	Levee	U Clay	U Clay	U Clay	U Clay	U Clay	U Clay	U Clay	U Clay		Total sample size
sample size (n)	122	146	30	55	91	55	43	72	85		577
K_{sbt} (cm/s)											
min	1E-07	9E-08	4E-07	3E-08	4E-08	4E-08	2E-08	2E-08	5E-08		
max	1E-02	2E-04	5E-06	6E-05	8E-04	1E-05	1E-04	4E-05	2E-04	RI Levee GM	RI U Clay GM
geomean (GM)	3E-05	7E-07	2E-06	1E-06	1E-05	5E-07	6E-07	2E-06	2E-06	3E-05	2E-06

Table 10-1. Hydraulic Conductivity Estimated from Soil Behavior Type (K_{sbt})

CPT Sounding	RI-2	RI-3	RI-4	RI-5	RIS-1	RIS-4	RIS-5	RIS-6	
Depth Interval (feet)	49-88	8-55	14-54	20-55	14-47	12-62	17-61	19-86	
Hydrogeologic Unit	Main Sand	M Sand	M Sand	M Sand	M Sand	M Sand	M Sand	M Sand	Total sample size
sample size (n)	224	287	244	211	199	258	268	400	2091
K_{sbt} (cm/s)									
min	4E-06	2E-06	1E-05	5E-07	2E-05	7E-06	1E-06	8E-06	
max	3E-02	2E-02	1E-01	3E-01	8E-01	3E-01	4E-01	6E-01	RI M Sand GM
geomean (GM)	3E-03	1E-04	4E-03	4E-03	3E-03	1E-02	2E-03	4E-03	2E-03

Summary of Hydraulic Conductivity Estimated from Soil Behavior Type (K_{sbt})

Levee HU beneath Prospect and Ryer Island (GM)	2E-05	cm/s	7E-07	ft/s
Upper Clay HU beneath Prospect and Ryer Island (GM)	2E-06	cm/s	5E-08	ft/s
Main Sand HU beneath Prospect and Ryer Island (GM)	3E-03	cm/s	1E-04	ft/s

Table 10-2. Hydraulic Conductivity Estimated from Soil Behavior Type (K_{sbt}) Adjacent to Well-Screen Intervals

Well ID	PI-1A	PI-3A	PI-5A	PI-6A	PI-10A	PI-2A	PI-7A	PI-8A	PI-9A
Adjacent CPT sounding	PI-1	PI-3	PI-5	PI-6	PI-10	PI-2	PI-7	PI-8	PI-9
Screen Interval (feet-bgs)	13-23	12-22	28-38	16-26	18-28	8-18	12-22	12-22	11-21
Hydrogeologic Unit	Upper Clay	Upper Clay	Upper Clay	Upper Clay	Upper Clay	Levee/U Clay	Levee/U Clay	Levee/U Clay	Levee/U Clay
sample size (n)	61	61	61	61	61	61	61	61	61
K_{sbt} (cm/s)									
min	2E-07	9E-08	2E-07	9E-08	1E-06	2E-07	6E-08	3E-07	6E-08
max	1E-05	1E-06	3E-05	1E-05	3E-03	3E-04	2E-06	1E-05	2E-04
geomean (GM)	6E-07	3E-07	2E-06	5E-07	5E-05	2E-06	3E-07	7E-07	6E-07
	U Clay		Levee/U Clay			PI		PI	
	Total sample size		Total sample size			U Clay GM		Levee/U Clay GM	
	305		244			2E-06		7E-07	

Well ID	PI-1B	PI-2B	PI-3B	PI-5B	PI-6B	PI-7B	PI-8B	PI-9B	PI-10B
Adjacent CPT sounding	PI-1	PI-2	PI-3	PI-5	PI-6	PI-7	PI-8	PI-9	PI-10
Screen Interval (feet-bgs)	61-71	49-59	42-52	67-77	46-56	47-57	46-56	46-56	45-55
Hydrogeologic Unit	Main Sand	Main Sand	Main Sand	Main Sand	Main Sand	Main Sand	Main Sand	Main Sand	Main Sand
sample size (n)	58	55	60	61	54	61	61	61	61
K_{sbt} (cm/s)									
min	7E-03	2E-04	2E-05	5E-05	7E-05	3E-05	6E-03	6E-04	2E-03
max	2E-01	3E-01	9E-02	1E-02	1E-01	3E-01	1E-01	7E-02	3E-02
geomean (GM)	9E-02	2E-02	3E-03	2E-03	6E-03	1E-02	3E-02	6E-03	7E-03
	Main Sand								
	Total sample size								PI M Sand GM
	532								1E-02

Table 10-2. Hydraulic Conductivity Estimated from Soil Behavior Type (K_{sbt}) Adjacent to Well-Screen Intervals

Well ID	PI-3C	PI-9C		
Adjacent CPT sounding	PI-3	PI-9		
Screen Interval (feet-bgs)	84-94	83-93		
Hydrogeologic Unit	Lower Sand	Lower Sand		Lower Sand Total sample size
sample size (n)	61	61		122
K_{sbt} (cm/s)				
min	5E-07	2E-06		
max	1E-03	1E-03		PI lower sand GM
geomean (GM)	1E-05	9E-05		3E-05

Well ID	99-4	99-8	99-11	99-6	99-5	99-3	99-7		
Adjacent CPT sounding	RI-4	RI-5	RI-2	RI-3	RI-3	RI-4	RI-5		
Screen Interval (feet-bgs)	8-13	9-14	53-58	9-14	33-38	34-39	33-38		
Hydrogeologic Unit	Upper Clay	Upper Clay	Main Sand	Main Sand	Main Sand	Main Sand	Main Sand	Upper Clay Total sample size	Main Sand Total sample size
sample size (n)	31	31	30	31	30	30	30	62	151
K_{sbt} (cm/s)									
min	1E-06	3E-06	3E-04	1E-04	6E-06	1E-03	5E-03		
max	7E-06	4E-04	1E-03	8E-04	5E-04	7E-02	3E-01	RI U Clay GM	RI M Sand GM
geomean (GM)	3E-06	3E-05	6E-04	3E-04	5E-05	1E-02	4E-02	9E-06	1E-03

Summary of Hydraulic Conductivity Estimated from Soil Behavior Type (K_{sbt}) adjacent to Well-Screen Intervals

Levee Material / Upper Clay beneath Prospect Island (GM)	7E-07	cm/s
Upper Clay beneath Prospect and Ryer Island (GM)	3E-06	cm/s
Lower Sand beneath Prospect and Ryer Island (GM)	3E-05	cm/s
Main Sand beneath Prospect and Ryer Island (GM)	5E-03	cm/s

Table 10-3. Summary of Pore Pressure Dissipation Testing Results

DWR ID	Depth (ft)	$(t_{50})^{0.50}$ (s)	t_{50} (s)	I_r	C_h (ft^2/s)	C_h (ft^2/year)	K_h (ft/s)	K_h (cm/s)	True K_h (cm/s) is >	K_{sbt} (cm/s) depth specific
PI-1	**15.09**	**8.5**	**72**	**500**	**3.94E-04**	**12430**	**1.23E-08**	**3.75E-07**		**3.81E-06**
PI-1	40.03	2.4	6	500	4.87E-03	153400	1.52E-07	4.63E-06	1E-05	
PI-1	55.12	2.7	7	500	3.89E-03	122700	1.22E-07	3.70E-06	1E-05	
PI-1	65.12	3.8	15	500	1.93E-03	60790	6.02E-08	1.83E-06	1E-05	
PI-2	**10.01**	**11.7**	**136**	**500**	**2.09E-04**	**6599**	**6.53E-09**	**1.99E-07**		**1.16E-06**
PI-2	40.03	3.9	15	500	1.85E-03	58450	5.79E-08	1.76E-06	1E-05	
PI-2	47.24	3.9	15	500	1.84E-03	58060	5.75E-08	1.75E-06	1E-05	
PI-2	58.07	4.5	20	500	1.39E-03	43920	4.35E-08	1.33E-06	1E-05	
PI-2	83.17	2.4	6	500	5.00E-03	157800	1.56E-07	4.76E-06	1E-05	
PI-2	**100.23**	**9.2**	**84**	**500**	**3.38E-04**	**10660**	**1.06E-08**	**3.22E-07**		**1.59E-06**
PI-3	36.91	4.3	18	500	1.55E-03	48840	4.84E-08	1.47E-06	1E-05	
PI-3	51.18	4.9	24	500	1.17E-03	36860	3.65E-08	1.11E-06	1E-05	
PI-3	**70.05**	**12.1**	**146**	**500**	**1.94E-04**	**6129**	**6.07E-09**	**1.85E-07**		**9.05E-03**
PI-3	**88.91**	**15.4**	**237**	**500**	**1.20E-04**	**3775**	**3.74E-09**	**1.14E-07**		**1.23E-03**
PI-4	61.84	2.2	5	500	5.77E-03	181800	1.80E-07	5.49E-06	1E-05	
PI-4	66.27	1.7	3	500	9.89E-03	312000	3.09E-07	9.41E-06	1E-05	
PI-4	85.47	2.7	7	500	3.84E-03	121000	1.20E-07	3.65E-06	1E-05	
PI-5	64.47	3.1	10	500	2.97E-03	93500	9.26E-08	2.82E-06	1E-05	
PI-5	81.36	1.7	3	500	9.89E-03	312000	3.09E-07	9.42E-06	1E-05	
PI-5	90.71	3.9	16	500	1.82E-03	57520	5.70E-08	1.74E-06	1E-05	
PI-6	36.75	2.3	5	500	5.22E-03	164800	1.63E-07	4.97E-06	1E-05	
PI-6	44.46	4.1	17	500	1.66E-03	52400	5.19E-08	1.58E-06	1E-05	
PI-6	60.04	2.7	7	500	3.98E-03	125500	1.24E-07	3.79E-06	1E-05	
PI-6	16.08	5.9	35	500	8.20E-04	25850	2.56E-08	7.80E-07	1E-05	
PI-7	**13.29**	**10.2**	**104**	**500**	**2.74E-04**	**8645**	**8.56E-09**	**2.61E-07**		**6.71E-07**
PI-7	13.45	5.4	29	500	9.83E-04	31010	3.07E-08	9.36E-07	1E-05	
PI-7	44.13	3.0	9	500	3.24E-03	102300	1.01E-07	3.09E-06	1E-05	
PI-8	37.4	1.8	3	500	8.74E-03	275700	2.73E-07	8.32E-06	1E-05	
PI-8	50.03	3.0	9	500	3.08E-03	97190	9.62E-08	2.93E-06	1E-05	

Table 10-3. Summary of Pore Pressure Dissipation Testing Results

DWR ID	Depth (ft)	$(t_{50})^{0.50}$ (s)	t_{50} (s)	I_r	C_h (ft^2/s)	C_h (ft^2/year)	K_h (ft/s)	K_h (cm/s)	True K_h (cm/s) is >	K_{sbt} (cm/s) depth specific
PI-8	70.05	2.4	6	500	5.06E-03	159600	1.58E-07	4.82E-06	1E-05	
PI-8	16.08	2.6	7	500	4.24E-03	133800	1.33E-07	4.04E-06	1E-05	
PI-9	14.11	3.8	14	500	2.01E-03	63440	6.28E-08	1.91E-06	1E-05	
PI-9	41.01	2.1	4	500	6.68E-03	210600	2.09E-07	6.36E-06	1E-05	
PI-9	50.03	2.3	5	500	5.43E-03	171100	1.69E-07	5.16E-06	1E-05	
PI-9	70.05	6.6	43	500	6.59E-04	20770	2.06E-08	6.27E-07	1E-05	
PI-9	89.24	2.5	6	500	4.46E-03	140600	1.39E-07	4.24E-06	1E-05	
PI-10	**8.37**	**13.4**	**179**	**500**	**1.59E-04**	**5008**	**4.96E-09**	**1.51E-07**		**2.54E-03**
PI-10	**20.51**	**11.2**	**125**	**500**	**2.27E-04**	**7149**	**7.08E-09**	**2.16E-07**		**6.16E-06**
RI-2	52.00	3.5	12	500	2.29E-03	72060	7.13E-08	2.17E-06	1E-05	
RI-2	75.95	4.7	22	500	1.27E-03	40190	3.98E-08	1.21E-06	1E-05	
RI-3	**13.62**	**24.1**	**583**	**500**	**4.88E-05**	**1538**	**1.52E-09**	**4.64E-08**		**2.31E-04**
RI-3	38.06	1.9	4	500	7.54E-03	237800	2.35E-07	7.17E-06	1E-05	
RI-3	50.03	1.8	3	500	8.31E-03	262100	2.60E-07	7.91E-06	1E-05	
RI-3	87.11	1.8	3	500	8.31E-03	262100	2.60E-07	7.91E-06	1E-05	
RI-4	25.92	4.3	19	500	1.51E-03	47490	4.70E-08	1.43E-06	1E-05	
RI-4	37.89	4.0	16	500	1.74E-03	54740	5.42E-08	1.65E-06	1E-05	
RI-5	**11.81**	**8.8**	**78**	**500**	**3.66E-04**	**11550**	**1.14E-08**	**3.49E-07**		**1.02E-04**
RI-5	24.93	1.6	3	500	1.09E-02	344900	3.41E-07	1.04E-05	1E-05	
RI-5	40.35	1.9	4	500	7.50E-03	236500	2.34E-07	7.14E-06	1E-05	
RI-5	79.89	2.1	4	500	6.66E-03	210100	2.08E-07	6.34E-06	1E-05	
RI-5	90.06	1.2	1	500	2.03E-02	641000	6.35E-07	1.93E-05	1E-05	
RIS-1	10.17	4.9	24	500	1.17E-03	36890	3.65E-08	1.11E-06	1E-05	
RIS-1	32.81	2.0	4	500	7.25E-03	228700	2.26E-07	6.90E-06	1E-05	
RIS-1	50.03	7.4	55	500	5.18E-04	16340	1.62E-08	4.93E-07	1E-05	
RIS-4	17.06	4.4	19	500	1.47E-03	46220	4.58E-08	1.39E-06	1E-05	
RIS-5	**12.14**	**12.6**	**158**	**500**	**1.80E-04**	**5673**	**5.62E-09**	**1.71E-07**		**4.42E-05**

Table 10-3. Summary of Pore Pressure Dissipation Testing Results

DWR ID	Depth (ft)	$(t_{50})^{0.50}$ (s)	t_{50} (s)	I_r	C_h (ft^2/s)	C_h (ft^2/year)	K_h (ft/s)	K_h (cm/s)	True K_h (cm/s) is >	K_{sbt} (cm/s) depth specific
RIS-5	19.03	5.6	31	500	9.13E-04	28780	2.85E-08	8.68E-07	1E-05	
RIS-5	35.1	1.8	3	500	9.07E-03	285900	2.83E-07	8.63E-06	1E-05	
RIS-5	43.8	1.7	3	500	9.53E-03	300400	2.97E-07	9.06E-06	1E-05	
RIS-5	70.21	1.8	3	500	8.44E-03	266200	2.64E-07	8.03E-06	1E-05	
RIS-6	12.8	0.7	0.4	500	6.51E-02	2053000	2.03E-06	6.20E-05	1E-05	
RIS-6	**25.59**	**19.0**	**361**	**500**	**7.87E-05**	**2483**	**2.46E-09**	**7.49E-08**		**1.65E-01**
RIS-6	**35.76**	**25.0**	**626**	**500**	**4.54E-05**	**1431**	**1.42E-09**	**4.32E-08**		**3.99E-01**
RIS-6	**77.43**	**15.9**	**254**	**500**	**1.12E-04**	**3531**	**3.50E-09**	**1.07E-07**		**9.69E-04**

Notes:

ft = feet

s = seconds

I_r = stiffness index, equal to shear modulus G divided by the undrained strength of clay (S_u)

C_h = coefficient of consolidation in the horizontal direction

K_h = hydraulic conductivity in the horizontal direction

Test results in **bold** have t_{50} times greater than 60 seconds indicating that they are not likely affected by full to partial drainage phenomenon; therefore, an estimation of K_h was made using the appropriate formula.

For comparison purposes, the depth specific K_{sbt} value is provided for the test results in **bold**

All other test results have t_{50} times which are less than 60 seconds indicating partial to full drainage phenomenon is occuring which affects testing results; therefore, true K_h values are > $1X10^{-5}$ cm/s

Table 10-4. Hydraulic Conductivity Estimated from Slug Testing (K_{st})

Well ID	PI-1B	PI-2B	PI-3B	PI-3C	PI-5B	PI-6B	PI-7B	PI-8B
Screen Depth Interval (feet)	61-71	49-59	42-52	84-94	67-77	46-56	47-57	46-56
Hydrogeologic Unit	Main Sand	Main Sand	Main Sand	Lower Sand	Main Sand	Main Sand	Main Sand	Main Sand
K_{st} (cm/s)								
min	9E-03	2E-02	6E-03	8E-03	3E-03	8E-03	6E-03	2E-02
max	1E-02	3E-02	8E-03	2E-02	9E-03	1E-02	1E-02	2E-02
geomean (GM)	1E-02	3E-02	7E-03	2E-02	6E-03	1E-02	1E-02	2E-02

Well ID	PI-9B	PI-9C	PI-10B	MW 99-1	MW 99-5	MW 99-7	MW 99-11
Screen Depth Interval (feet)	46-56	83-93	45-55	33-38	33-38	33-38	53-58
Hydrogeologic Unit	Main Sand	Lower Sand	Main Sand	Main Sand	Main Sand	Main Sand	Main Sand
K_{st} (cm/s)							
min	1E-02	8E-04	1E-02	4E-02	9E-03	2E-02	2E-02
max	2E-02	2E-03	3E-02	5E-02	1E-02	3E-02	3E-02
geomean (GM)	2E-02	2E-03	2E-02	4E-02	1E-02	2E-02	2E-02

Summary of Hydraulic Conductivity Estimated from Slug Testing (K_{st})

Main Sand HU beneath Prospect Island (GM)	1E-02	cm/s
Main Sand HU beneath Ryer Island (GM)	2E-02	cm/s
Lower Clay (sand) beneath Prospect Island (GM)	5E-03	cm/s
Main Sand Hu beneath Prospect and Ryer Island (GM)	1E-02	cm/s

Table 10-5. Hydraulic Conductivity (K) Estimates from Grain Size Analysis using SizePerm

Lab ID	Sample ID	Sample Depth Below Water Surface (ft)	Classification Group[c]	Geometric Mean K (ft/sec)[e]	Geometric Mean K (cm/sec)[e]	Uniformity (η)	K results for indvidual empirical equations calculated in SizePerm (cm/s)[b]									
							Hazen	Slichter[d]	Terzaghi[d]	Beyer	Sauerbrei	Kruger[d]	Kozney	Zunker[d]	USBR	Pavchich[f]
13-180	MSPI-1CL/MSPI-1	21.1	SP	**7.94E-04**	**2.42E-02**	1.824	1.41E-01	5.57E-02	9.83E-02	1.24E-01	9.88E-02	2.55E-03	1.22E-04	5.50E-05	3.80E-02	3.30E-02
13-167	MSPI-1LB	16.8	SP	**5.51E-04**	**1.68E-02**	2.346	3.74E-02	1.38E-02	2.43E-02	3.35E-02	2.73E-02	1.39E-03	9.99E-03	4.15E-03	1.15E-02	1.09E-02
13-162[a]	MSPI-1RB	18.8														
13-185	MSPI-6CL	14.2	SP	**1.90E-03**	**5.80E-02**	1.509	1.46E-01	6.04E-02	1.07E-01	1.28E-01	1.05E-01	2.68E-03	1.55E-02	5.55E-03	3.48E-02	3.13E-02
13-174	MSPI-6LB	15.7	SP	**2.07E-03**	**6.30E-02**	1.855	1.49E-01	5.88E-02	1.04E-01	1.32E-01	1.04E-01	4.87E-03	3.12E-02	1.26E-02	4.11E-02	3.52E-02
13-181	MSPI-6RB	16.7	SP	**1.11E-03**	**3.39E-02**	2.013	6.63E-02	2.56E-02	4.50E-02	5.88E-02	7.10E-02	2.50E-03	1.62E-02	6.30E-03	2.74E-02	2.53E-02
13-182	MSPI-7CL	22.4	SP	**5.86E-04**	**1.79E-02**	2.368	4.26E-02	1.57E-02	2.76E-02	3.82E-02	4.21E-02	5.73E-04	4.25E-03	1.69E-03	2.21E-02	1.69E-02
13-184	MSPI-7LB	15.8	SP	**1.65E-03**	**5.02E-02**	1.806	1.45E-01	5.75E-02	1.01E-01	1.28E-01	1.02E-01	1.38E-03	1.01E-02	3.76E-03	3.90E-02	3.38E-02
13-187[a]	MSPI-7RB	13.6														
13-170	MSPI-8CL	22.1	SP	**2.73E-03**	**8.31E-02**	1.612	1.48E-01	6.03E-02	1.07E-01	1.30E-01	1.06E-01	1.00E-02	1.54E-01	7.28E-02	3.69E-02	3.27E-02
13-172[a]	MSPI-8LB	23.5														
13-179	MSPI-8RB	15.3		**3.75E-08**	**1.14E-06**	23.334	1.09E-05	2.17E-06	3.13E-06	1.48E-05	9.63E-06	1.17E-06	1.98E-07	1.36E-07	1.95E-05	2.71E-05
13-183	MSPI-9CL	17.3	SP	**6.85E-04**	**2.09E-02**	2.283	4.56E-02	1.70E-02	2.99E-02	4.08E-02	3.92E-02	1.53E-03	8.22E-03	3.19E-03	1.83E-02	1.53E-02
13-161	MSPI-9LB	17.9	SP	**2.65E-03**	**8.08E-02**	1.611	1.47E-01	5.99E-02	1.06E-01	1.29E-01	1.05E-01	9.36E-03	1.30E-01	6.36E-02	3.66E-02	3.24E-02
13-175	MSPI-9RB	15.0		**1.10E-04**	**3.35E-03**	3.527	6.75E-03	2.19E-03	3.81E-03	6.39E-03	4.69E-03	6.99E-04	3.25E-03	1.93E-03	2.46E-03	2.66E-03
13-163[a]	MSPI-10CL	23.3														
13-178	MSPI-10RB	13.8	SP	**8.70E-04**	**2.65E-02**	1.85	8.00E-02	3.15E-02	5.56E-02	7.05E-02	7.85E-02	8.32E-04	2.33E-03	9.41E-04	2.87E-02	2.65E-02
13-189[a]	MSDS-1	25.2														
13-188	MSDS-2	34.9	SP	**1.90E-03**	**5.78E-02**	1.945	1.47E-01	5.73E-02	1.01E-01	1.30E-01	1.02E-01	3.83E-03	2.11E-02	8.01E-03	4.16E-02	3.55E-02
13-164	MSDS-3	26.9	SP	**1.74E-03**	**5.32E-02**	1.534	1.43E-01	5.88E-02	1.04E-01	1.26E-01	1.02E-01	2.12E-03	1.59E-02	6.10E-03	3.43E-02	3.08E-02
13-159[a]	MSDS-4	32.3														
13-165	MSDS-5	42.7		**1.69E-10**	**5.16E-09**	23.542	1.32E-08	2.62E-09	3.78E-09	1.79E-08	5.16E-09	2.01E-08	2.27E-09	1.54E-09	2.37E-09	1.13E-08
13-169	MSDS-6	38.4	SP	**1.99E-03**	**6.08E-02**	1.465	1.43E-01	5.93E-02	1.05E-01	1.25E-01	1.03E-01	2.77E-03	3.35E-02	1.39E-02	3.32E-02	3.01E-02
13-166	DWSPI-2LB/DWSPI-2	9.9		**8.14E-10**	**2.48E-08**	55.749	3.32E-08	6.52E-09	9.29E-09	3.32E-08	2.48E-08	6.40E-08	8.30E-09	5.72E-09	2.11E-08	7.06E-08
13-173	DWSPI-2CL	36.2		**8.80E-06**	**2.68E-04**	4.301	2.30E-03	6.93E-04	1.20E-03	2.27E-03	2.86E-03	8.71E-06	2.42E-06	1.15E-06	1.59E-03	1.97E-03
13-160	DWSPI-2RB	6.0		**3.03E-08**	**9.23E-07**	185.279	2.51E-07	4.94E-08	7.04E-08	1.14E-07	9.23E-07	2.64E-07	3.49E-08	2.41E-08	1.91E-06	2.71E-06
13-176	DWSPI-3CL	36.8		**6.39E-05**	**1.95E-03**	4.008	1.14E-02	3.53E-03	6.13E-03	1.11E-02	1.08E-02	3.35E-05	1.24E-05	5.81E-06	6.53E-03	6.91E-03
13-168	DWSPI-3LB	9.7		**1.53E-09**	**4.65E-08**	43.723	4.80E-08	9.43E-09	1.35E-08	5.34E-08	4.65E-08	7.64E-08	1.16E-08	7.96E-09	4.93E-08	1.38E-07
13-190	DWSPI-3RB	4.5		**3.24E-09**	**9.87E-08**	39.033	7.50E-08	1.47E-08	2.10E-08	8.72E-08	9.87E-08	1.07E-07	1.63E-08	1.13E-08	1.09E-07	2.82E-07
13-177	DWSPI-4LB/DWSPI-4CL	8.6		**2.77E-09**	**8.45E-08**	50.052	6.82E-08	1.34E-08	1.91E-08	7.17E-08	8.45E-08	1.06E-07	1.54E-08	1.06E-08	1.03E-07	2.29E-07
13-186[a]	DWSPI-4CL	36.0														
13-171	DWSPI-4RB	21.0		**1.74E-08**	**5.29E-07**	94.443	9.76E-08	1.92E-08	2.73E-08	7.43E-08	5.29E-07	1.74E-07	2.04E-08	1.41E-08	1.10E-06	1.49E-06

Notes:

Sample IDs in red were revised due to incorrect sample labeling in the field. Sample IDs in blue show the original sample name.

[a] grain size analysis not performed due to lack of sample material (sample IDs in green)

[b] shaded values indicate K values that were not applicable for the sample grain size distribution; these values were not incorporated into the mean K values

[c] SP = poorly graded sand; samples left blank were not provided with a classification group

[d] Kasenow (2010; Grain-Size Analysis software) does not incorporate these equations into mean K values

[e] Prudic (1991) suggests that the geometric mean may be more appropriate than the arithmetic mean (p. 2, Introduction); effective K may fall between the arithmetic and geometric mean

[f] Pavchich formula (used in Grain-Size Analysis software) estimated using mean K formula - K (cm/s) = 0.35t($d_{17}{}^2$ mm) in Kasenow (2010, p. 59); not used in SizePerm

Table 11-1. Ryer Island Drainage Ditch Station Details

Monitoring Station		Location (NAD 83)		Reference Point Elevation (NAVD 88 Ft)
Station Number	Station Name	Latitude	Longitude	
B91440	ELKHORN SLOUGH 1	38.2668269	-121.6240287	-2.79
B91445	WEST CANAL	38.2687267	-121.6363464	-2.38
B91460	ELKHORN SLOUGH 2	38.2797525	-121.6275316	-1.18

Notes:
Surveyed by DWR DOE Geodetic Branch using RTK-GPS equipment and methods
NAD83,NAVD88, US Feet, Epoch Date 2007.00
Date of Survey: July 2013

Table 12-1. Seepage Modeling Scenarios and Boundary Conditions

Seepage Transect	Stage Condition	Seepage Analysis Scenario	Miner Slough Stage Elevation (feet)	Deep Water Ship Channel Stage Elevation (feet)	Prospect Island Stage/GW Elevation (feet)	Western Boundary Head Elevation (feet)	Eastern Boundary Head Elevation (feet)	Lower Boundary	SEEP/W Mesh Size (feet)
North	High Stage	Past	10 [1]	-	Ground Surface [5]	No Flow	-3 [6]	No Flow	5
		Existing	10 [1]	-	5 [3]	No Flow	-3 [6]	No Flow	5
		Restored	10 [1]	-	10	No Flow	-3 [6]	No Flow	5
	Average	Past	5	-	Ground Surface [5]	No Flow	-3 [6]	No Flow	5
		Existing	5	-	4	No Flow	-3 [6]	No Flow	5
		Restored	5	-	5	No Flow	-3 [6]	No Flow	5
Middle	High Stage	Past	10 [1]	-	Ground Surface [5]	No Flow	-5 [6]	No Flow	5
		Existing	10 [1]	-	5 [3]	No Flow	-5 [6]	No Flow	5
		Restored	10 [1]	-	10 [4]	No Flow	-5 [6]	No Flow	5
	Average	Past	5	-	Ground Surface [5]	No Flow	-5 [6]	No Flow	5
		Existing	5	-	4	No Flow	-5 [6]	No Flow	5
		Restored	5	-	5	No Flow	-5 [6]	No Flow	5
South	High Stage	Past	10 [1]	7 [2]	Ground Surface [5]	No Flow	-7 [7]	No Flow	5
		Existing	10 [1]	7 [2]	5 [3]	No Flow	-7 [7]	No Flow	5
		Restored	10 [1]	7 [2]	10 [4]	No Flow	-7 [7]	No Flow	5
	Average	Past	5	4	Ground Surface [5]	No Flow	-7 [7]	No Flow	5
		Existing	5	4	4	No Flow	-7 [7]	No Flow	5
		Restored	5	5	5	No Flow	-7 [7]	No Flow	5

Notes:

1 - Highest stage in Miner Slough (9.6 ft on 12/26/2012) between June 1, 2010 and November 1, 2013 (monitoring network period of record)

2 - Stage in Deep Water Ship Channel (7.2 ft on 12/26/2012 15:30) corresponding to highest stage in Miner Slough

3 - Stage in Prospect Island (4.8 ft on 12/26/2012 15:30) corresponding to highest stage in Miner Slough - existing conditions

4 - Estimated stage in Prospect Island corresponding to highest stage in Miner Slough with levee breach

5 - Estimated groundwater level on Prospect Island based on 1999 USACE Trench logs water level observation (Appendix C)

6 - Stage in Ryer Island Drainage Ditches (see section 11 of text)

7 - Estimated from land surface elevation and stage in the Elkhorn Slough 1 Ryer Island Drainage Ditch station (see section 11 of text)

Table 12-2. Hydraulic Conductivities Used in Seepage Analysis

Transect	Soil Layer	Horizontal Conductivity Kx (ft/s)	Ky/Kx in SEEP/W
North	Levee	7.0E-07	0.25
	Upper Clay	5.0E-08	0.25
	Main Sand	1.0E-04	0.25
	Lower Clay	5.0E-08	0.25
Middle	Levee	7.0E-07	0.25
	Upper Clay	5.0E-08	0.25
	Main Sand	1.0E-04	0.25
	Lower Clay	5.0E-08	0.25
South	Levee	7.0E-07	0.25
	Upper Clay	5.0E-08	0.25
	Main Sand	1.0E-04	0.25
	Lower Clay	5.0E-08	0.25

Notes:

The Kx values used for each layer were derived from the hydraulic conductivity evaluation documented in Section 10 of the memorandum report.

Table 12-3. Seepage Modeling Results - Total Head

Seepage Transect	Stage Conditions	Seepage Analysis Scenario	SEEP/W Model Node	X (ft)	Y (ft)	Total Head (ft) in Main Sand under Ryer Island Levee	Difference (ft) in total head between different scenarios
North	High Stage	Past	8213	2152.498	-40.89523	8.827	
		Existing	8213	2152.498	-40.89523	8.836	0.009
		Restored	8213	2152.498	-40.89523	8.859	0.023
	Average	Past	8213	2152.498	-40.89523	4.310	
		Existing	8213	2152.498	-40.89523	4.314	0.005
		Restored	8213	2152.498	-40.89523	4.319	0.005
Middle	High Stage	Past	8399	2194.621	-39.91507	8.432	
		Existing	8399	2194.621	-39.91507	8.570	0.138
		Restored	8399	2194.621	-39.91507	8.608	0.037
	Average	Past	8399	2194.621	-39.91507	4.013	
		Existing	8399	2194.621	-39.91507	4.092	0.079
		Restored	8399	2194.621	-39.91507	4.100	0.007
South	High Stage	Past	13118	3602.558	-38.14353	8.876	
		Existing	13118	3602.558	-38.14353	8.877	0.001
		Restored	13118	3602.558	-38.14353	8.879	0.002
	Average	Past	13118	3602.558	-38.14353	4.242	
		Existing	13118	3602.558	-38.14353	4.243	0.001
		Restored	13118	3602.558	-38.14353	4.244	0.000

Table 12-4. Seepage Modeling Results - Flow

Seepage Transect	Stage Condition	Seepage Analysis Scenario	Miner Slough Stage Elevation (feet)	Deep Water Ship Channel Stage Elevation (feet)	Prospect Island Stage/GW Elevation (feet)	Western Boundary Head Elevation (feet)	Eastern Boundary Head Elevation (feet)	Lower Boundary	SEEP/W Mesh Size (feet)	Flow through Ryer Island Levee (Vertical) (CFS)	Gallons/day/ 1000 ft	Change in flow (%) between different scenarios
North	High Stage	Past	10 [1]	-	Ground Surface [5]	No Flow	-3 [6]	No Flow	5	3.38E-05	21,838	
		Existing	10 [1]	-	5 [3]	No Flow	-3 [6]	No Flow	5	3.38E-05	21,856	0.1%
		Restored	10 [1]	-	10	No Flow	-3 [6]	No Flow	5	3.39E-05	21,901	0.2%
	Average	Past	5	-	Ground Surface [5]	No Flow	-3 [6]	No Flow	5	2.01E-05	12,989	
		Existing	5	-	4	No Flow	-3 [6]	No Flow	5	2.01E-05	12,998	0.1%
		Restored	5	-	5	No Flow	-3 [6]	No Flow	5	2.01E-05	13,007	0.1%
Middle	High Stage	Past	10 [1]	-	Ground Surface [5]	No Flow	-5 [6]	No Flow	5	3.69E-05	23,859	
		Existing	10 [1]	-	5 [3]	No Flow	-5 [6]	No Flow	5	3.73E-05	24,122	1.1%
		Restored	10 [1]	-	10 [4]	No Flow	-5 [6]	No Flow	5	3.74E-05	24,192	0.3%
	Average	Past	5	-	Ground Surface [5]	No Flow	-5 [6]	No Flow	5	2.38E-05	15,403	
		Existing	5	-	4	No Flow	-5 [6]	No Flow	5	2.41E-05	15,556	1.0%
		Restored	5	-	5	No Flow	-5 [6]	No Flow	5	2.41E-05	15,570	0.1%
South	High Stage	Past	10 [1]	7 [2]	Ground Surface [5]	No Flow	-7 [7]	No Flow	5	2.43E-05	15,730	
		Existing	10 [1]	7 [2]	5 [3]	No Flow	-7 [7]	No Flow	5	2.43E-05	15,732	0.0%
		Restored	10 [1]	7 [2]	10 [4]	No Flow	-7 [7]	No Flow	5	2.43E-05	15,734	0.0%
	Average	Past	5	4	Ground Surface [5]	No Flow	-7 [7]	No Flow	5	1.63E-05	10,548	
		Existing	5	4	4	No Flow	-7 [7]	No Flow	5	1.63E-05	10,550	0.0%
		Restored	5	5	5	No Flow	-7 [7]	No Flow	5	1.63E-05	10,550	0.0%

Notes:

1 - Highest stage in Miner Slough (9.6 ft on 12/26/2012) between June 1, 2010 and November 1, 2013 (monitoring network period of record)

2 - Stage in Deep Water Ship Channel (7.2 ft on 12/26/2012 15:30) corresponding to highest stage in Miner Slough

3 - Stage in Prospect Island (4.8 ft on 12/26/2012 15:30) corresponding to highest stage in Miner Slough - existing conditions

4 - Estimated stage in Prospect Island corresponding to highest stage in Miner Sloughs with levee breach

5 - Estimated groundwater level on Prospect Island based on 1999 USACE Trench logs water level observation (Appendix C)

6 - Stage in Ryer Island Drainage Ditches (see section 11 of text)

7 - Estimated from land surface elevation and stage in the Elkhorn Slough 1 Ryer Island Drainage Ditch station (see section 11 of text)

Appendices

Appendix A. URS Geomorphic Maps

URS

Technical Memorandum

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Prepared For	Department of Water Resources Division of Integrated Regional Water Management
Project	Non-Urban Levee Evaluations Project Contract No. 4600008101, Task Order No. U114
Date	October 18, 2013
Subject	Geomorphic Assessment and Surficial Mapping of Prospect and Ryer Island, California. Addendum to Non-Urban Levee Evaluations Project Level 2-II Geomorphic Assessment and Surficial Mapping of the West Delta Study Area
Prepared By	Tim Gere (URS), October 2013
Reviewed By	Judy Zachariasen (URS)

INTRODUCTION

This memorandum presents a preliminary geomorphic assessment and surficial geologic map (Plate 1) of Prospect and Ryer Islands (Study Area). These materials were prepared as an addendum to the Level 2-II Geomorphic Assessment and Surficial Mapping of the West Delta Study Area Technical Memorandum (Fugro William Lettis & Associates (FWLA), URS, 2010).

TECHNICAL APPROACH

The technical approach used to create the 1:24,000-scale map of surficial geology of the Study Area (Plate 1) focused on review and analysis of the following materials:

- 1937 aerial photography (Table 1a)
- Early and modern topographic maps (Table 1b)
- Published surficial geologic maps (Atwater, 1982)
- Early and modern soil survey data (Holmes et al., 1913; Natural Resources Conservation Service [NRCS] 2007)

Table 1a. 1937 Aerial Photography.

County Code	Roll Number	Frame Number
ABO	53	24 to 29, 64 to 67
ABO	112	75 to 79

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Table 1b. USGS Topographic Maps.

Quadrangle Name	Publication Date	Photo Revision Date	Series	Scale	Survey Date
Isleton	1910	NA	NA	1:31,680	1906 - 1908
Rio Vista	1910	NA	NA	1:31,680	1906 - 1908
Cache Slough (Liberty Island)	1916	NA	NA	1:31,680	1906
Vorden (Courtland)	1916	NA	NA	1:31,680	1906

For further discussion of the technical approach, geologic setting, surficial geologic mapping, and conceptual geomorphic model, refer to the Level 2-II Geomorphic Assessment and Surficial Mapping of the West Delta Study Area Technical Memorandum. Levees in the Study Area have been assigned a relative underseepage susceptibility rating based on the type and age of the deposits beneath them (Plate 1).

APPLICATION TO STUDY AREA LEVEES

Based on the results of the geomorphic assessment, an underseepage susceptibility rating was assigned to each surficial geologic unit based on geologic age and depositional environment (Table 2).

Table 2. Underseepage Susceptibility Summary.

Unit Symbols	Unit Descriptions	Susceptibility Rating	Mileage	Percent
Hpm	Holocene peat and muck	Very High	3.08	20.7
Rob	Historical overbank deposits	Very High	2.55	17.1
Rcs	Historical crevasse splay deposits	Very High	0.30	2.0
W1937	Water 1937	Very High	0.13	0.9
Hs	Marsh deposits	High	0.94	6.3
Hob	Holocene overbank deposits	High	6.92	46.4
Rsl	Historical slough deposits	High	0.24	1.6
Hcs	Holocene crevasse splay deposits	High	0.10	0.7
Hsl	Holocene slough deposits	Moderate	0.36	2.4
Hn	Holocene basin deposits	Low	0.29	1.9

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LIMITATIONS

This geomorphic assessment has been performed in accordance with the standard of care commonly used as the state-of-practice in the engineering profession. Standard of care is defined as the ordinary diligence exercised by fellow practitioners in this geographic area performing the same services under similar circumstances during the same time period.

Discussions of shallow subsurface conditions in this technical memorandum are based on interpretation of geomorphic data supplemented with very limited subsurface exploration information. Variations in subsurface conditions may exist between those shown on maps and actual conditions. Due to the scale of mapping, the project team may not be able to identify all adverse conditions in levee foundation materials.

No warranty, either express or implied, is made in the furnishing of this technical memorandum that is the result of geotechnical evaluation services. URS makes no warranty that actual encountered site and subsurface conditions will exactly conform to the conditions described herein, nor that this technical memorandum's interpretations and recommendations will be sufficient for construction planning aspects of the work. The design engineer or contractor should perform a sufficient number of independent explorations and tests as they believe necessary to verify subsurface conditions rather than relying solely on the information presented in this report.

URS does not attest to the accuracy, completeness, or reliability of maps, data sources, geotechnical borings and other subsurface data produced by others that are included in this technical memorandum. URS has not performed independent validation or verification of data reported by others.

Data presented in this technical memorandum are time-sensitive in that they apply only to locations and conditions that were identified at the time of preparation of this report. The maps produced generally present conditions as they occurred in the early 1900s, as primary data interpreted for this report are from this period. Data should not be applied to any other projects in or near the area of this study nor should they be applied at a future time without appropriate verification, at which point the one verifying the data takes on the responsibility for it and any liability for its use.

This technical memorandum is for the use and benefit of DWR. Use by any other party is at their own discretion and risk.

This technical memorandum should not to be used as a basis for design, construction, remedial action or major capital spending decisions.

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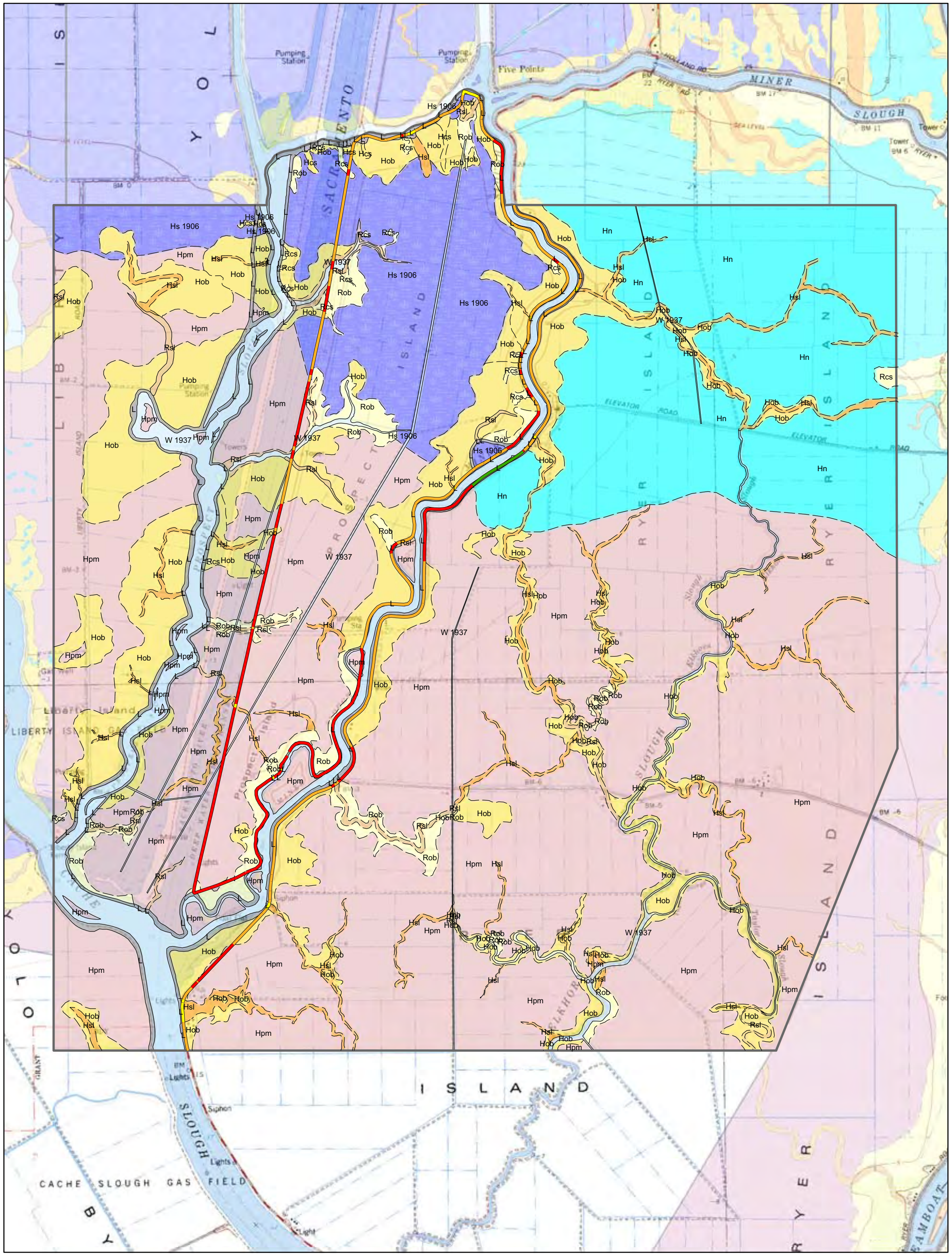

This map shows surficial geologic deposits and levees as they existed in 1937. Map units and boundaries are drawn by interpretation of historical aerial photography supplemented by data from historical maps and surveys. For reference, the mapping is superimposed on modern U.S. Geological Survey 7.5' topographic base maps (individual maps referenced below).
Screened back semi-transparent mapping shown on this plate is from adjacent study areas, which are not assessed in this investigation. For clarity, only the surficial geologic map units of this study appear in the explanation.
See the technical memorandum Geomorphic Assessment and Surficial Mapping of the West Delta Study Area (2010) for complete descriptions of map units, process descriptions and methodology.

Explanation

Underseepage Susceptibility Along Ryer Island Levee Alignment

Very High | High | Moderate | Low

- Geologic contact, certain
- Geologic contact, approximate
- Geologic contact, uncertain
- Geologic contact, concealed
- Geologic contact, concealed, uncertain
- Map Boundary

W 1937 — Water; date indicates year of historical dataset.

Geologic Unit

HISTORICAL

- L — Levee (made of artificial fill), circa 1937.
- Rob — Overbank deposits; silt, sand, and lesser clay; deposited during high-stage water flow, overtopping channel banks.
- Rcs — Crevasse splay deposits; fine sand and silt with clay deposited from breaching of natural or artificial levees.
- Rsl — Slough deposits; silt, clay, and sand, fining upward facies, low-energy channel deposits.

HOLOCENE

- Hob — Overbank deposits; silt, sand, and clay; deposited during high-stage water flow, overtopping channel banks.
- Hcs — Crevasse splay deposits; fine sand and silt with clay deposited from breaching of natural levees.
- Hsl — Slough deposits; silt, clay, and sand, fining upward facies, low-energy channel deposits.
- Hpm — Peat and muck; interbedded peat and organic-rich silt and clay, former tidal marsh deposits, mostly now leveed, drained, and farmed.
- Hn — Basin deposits; fine sand, silt and clay.
- Hs 1906 — Marsh deposits; silt and clay, possibly with organic-rich beds; perennially or seasonally submerged. Date indicates year of historical dataset used to map the marsh.

Stratigraphic Correlation Chart

Time: Epoch	Channel deposits	Floodplain and alluvial-fan deposits	Flood basin deposits	Cultural deposits
Historical	Rsl	Rob, Rcs	Hn, Hs, Hpm	L
Holocene	Hsl	Hob, Hcs		

Depositional Environment

N

Scale: 1:24,000
1 inch = 2,000 feet
WHEN PRINTED AT 17x22-INCH PAGE SIZE

2,000 1,000 0 2,000
Feet

Map projection: UTM NAD83, Zone 10 North

Topographic base: USGS 7.5-Minute Quadrangles for Isleton (published 1978; revised 1993), Rio Vista (published 1978; revised 1993), Courtland (published 1978; revised 1993), and Liberty Island (published 1978; revised 1993).

Air photo analysis and map compilation by T. Gere, J. Zachariasen
Digital preparation by B. Brezing

Department of Water Resources
Division of Integrated Regional Water Management
NORTH CENTRAL REGION OFFICE
Geology and Groundwater Investigations Section

URS

Surficial Geologic Map of the Prospect Island and Ryer Island Study Area

Prospect Island Tidal Habitat Restoration Project

Plate 1

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In association with
William Lettis & Associates, Inc.

Prepared For	Department of Water Resources Division of Flood Management
Project	Non-Urban Levee Evaluations Project Task Order U-103
Date	December 20, 2010
Subject	Level 2-II Geomorphic Assessment and Surficial Mapping of the West Delta Study Area
Prepared By	Cooper Brossy, Fugro William Lettis & Associates (FWLA), September 2010
Reviewed By	Justin Pearce, FWLA, September 2010; Jenn Mendonca, Judy Zachariasen, URS, September 2010; Steve Belluomini, DWR, December, 2010

INTRODUCTION

This draft technical memorandum presents the results of surficial geologic mapping and geomorphic assessment in the Non-Urban Levee Evaluations (NULE) Project's West Delta Study Area (Figure 1). Surficial geologic mapping and geomorphic assessment was performed by NULE Project team member Fugro William Lettis & Associates (FWLA).

The study area includes approximately 36 miles of non-urban Project levees in the low-lying portion of the southwestern Sacramento Valley, about 5 to 12 miles north of Rio Vista (Figure 1). The subject levees for this assessment primarily lie along Lindsey Slough, Barker Slough, Ulatis Creek, Main Prairie Slough, Haas Slough, Shag Slough, and Cache Slough (Figure 2 and Plate1). Extensive dredging and widening of sloughs has occurred throughout the Study Area. These dredging activities provided material used to construct the levees that presently confine the sloughs (Thompson and Dutra, 1983). In addition, a number of small and large canals and associated levees have been constructed across the Study Area to aid in irrigation, prevent flooding, and drain the previously saturated, low-lying deposits.

The primary goal of this assessment is to develop and analyze map data about the type and distribution of surface and shallow subsurface deposits underlying non-urban Project levees to develop an assessment of levee underseepage susceptibility hazard, and secondarily, to develop an initial conceptual model allowing reasonable stratigraphic interpretations within a consistent framework. Understanding fluvial processes and recognizing depositional environments in the geologic record are key to identifying locations along levees where underseepage is most likely to occur (Llopis et al., 2007). Plate 1 presents the surficial geologic map of the West Delta Study Area.

TECHNICAL APPROACH

This assessment involved the integration and analysis of aerial photography, topographic maps, geologic maps, soil maps, and historical documents (see list below). Synthesis of these data helped in the construction of a detailed surficial geologic map, assessment of the primary geomorphic processes responsible for distributing or modifying surficial deposits in the study area, and development of levee underseepage susceptibility hazard maps.

The project team analyzed the following data:

- 1937 aerial photography[1] (Table 1a)

Table 1a. Aerial Photography.

County Code	Roll Number	Frame Numbers
ABO	55	69 through 75
ABO	54	17 through 26
ABO	54	59 through 67
ABB/ABO	53	60 through 62
ABO	53	63 through 68

- Early and modern topographic maps (Table 1b)
- Published surficial geologic maps (Atwater, 1982; Helley and Harwood, 1985)
- Early and modern soil survey maps (Holmes et al., 1913; Bates et al., 1977)

Table 1b. USGS Topographic Maps.

Quadrangle Name	Publication Date	Revision Date	Series	Scale	Survey Date
Antioch	1908	N/A	7.5-Minute	1:62,500	1906-1907
Dozier (previously Maine Prairie)	1916	N/A	7.5-Minute	1:31,680	1906
Liberty Island (prev. Cache Slough)	1916	N/A	7.5-Minute	1:31,680	1906
Rio Vista	1910	N/A	7.5-Minute	1:31,680	1906-1908
Birds Landing	1953	1968	7.5-Minute	1:24,000	N/A
Dozier	1952	1968	7.5-Minute	1:24,000	N/A
Liberty Island	1978	1993	7.5-Minute	1:24,000	N/A
Rio Vista	1978	N/A	7.5-Minute	1:24,000	N/A

The West Delta Study Area's surficial geologic map (Plate 1) was developed at the nominal scale of 1937 aerial photography (approximately 1:20,000) and is presented at 1:24,000 scale. This map should not be used or displayed at scales greater than 1:24,000. Solid map unit contacts on the surficial geologic map are approximate and are accurate to within about 100 feet on either side of the line shown on the map. Dashed contacts are accurate to within about 250 feet on either side of

[1] All photographs are black-and-white stereo-pairs at approximately 1:20,000 scale, flown August 20, 21, and 25, 1937.

the line. Modern topography and topographic relationships within the study area appear in Figure 2. Semi-transparent mapping shown on Plate 1 is from the Deep Water Ship Channel (DWSC) Study Area which lies adjacent to the current study area. DWSC Study Area mapping was part of a previous assessment and not directly included or described in this investigation but is shown here for completeness[2].

Map units shown on Plate 1 primarily are based on analysis of 1937 aerial photography and soil surveys in conjunction with early topographic maps. The map is a compilation of the surficial geologic conditions up until 1937. These 1937 aerial photographs are the primary data set for interpreting surficial geologic deposits because they are the oldest high-quality images available, pre-dating much of the cultivation and landscape alteration in present-day Solano County. Field reconnaissance was conducted to check the office-based mapping. When synthesized, the map and photographic data provide key insights to the characteristics of deposits beneath the levees, and serve as a technical framework for assessing underseepage susceptibility in the West Delta Study Area.

For underseepage hazard assessment, levee foundations were assigned a susceptibility class based on their underlying surficial geologic deposits. Map data were imported into a geographic information system (GIS) and spatially intersected with NULE Project levee lines; susceptibility categories were then assigned to levee sections as shown in Table 2. Underseepage susceptibility category assignments were made based on geologic age and depositional environment, as well as relative hydraulic conductivity. The validity of these hazard assignments was tested during the Level 2-I work phase by analyzing levee past performance data as an indicator of underseepage susceptibility.

GEOLOGIC SETTING

The West Delta Study Area is located within, and close to the southwestern boundary of, the legally-defined Sacramento-San Joaquin Delta (State of California, 2009) in the southwestern Sacramento Valley. The Study Area spans three geomorphic and depositional environments: 1) alluvial fans; 2) flood basin; and 3) tidal marsh (Figures 3 and 4). The northwestern and western portions of the study area lie within the low-relief, relatively fine-grained alluvial fans deposited by distributary channels that flow across the southern portion of the Putah Creek alluvial fan and smaller channels draining the Montezuma Hills (Figures 2 and 3). Moving southeastward, these distal alluvial fans transition into the seasonally inundated flood basin environment and then into the tidally influenced delta marsh. Elevations range from about 15 feet above sea level to about 5 feet below sea level (Figure 2 and Plate 1). The land surface generally slopes southeast; much of the southeastern

[2] Refer to Technical Memorandum: *Surficial Geologic Map and Geomorphic Assessment of the Deep Water Ship Channel Study Area, Urban Non-Project Levee Geotechnical Evaluation, Solano and Yolo Counties, California*; June 9, 2010; Prepared by FWLA for URS

portion of the study area lies near or below sea level (Figure 2) and is shown as perennially saturated marsh on historical topographic maps (Table 1b).

The Holocene Putah Creek and late Pleistocene alluvial fan surfaces slope gently southeastward (Figure 3). The Putah Creek alluvial fan sediments consist of relatively fine-grained, weathered clastic materials eroded from weak shales, sandstones, and low-grade metamorphic rocks present in the northeastern Coast Ranges (Wagner et al., 1981; Wagner and Bortugno, 1982). The textures of these materials contrasts with relatively coarse-grained clastic sediment derived from granitic or volcanic sources on the east side of the Sacramento River. The smaller alluvial fans along the southwestern margin of the study area consist of relatively coarser-grained material eroded from the adjacent Montezuma Hills. Alluvium from Montezuma Hills are early-Pleistocene deposits consisting of poorly sorted quartz-lithic sand, silt, and pebble gravel, as well as some material from the nearby Coast Range mountains (Atwater, 1982; Graymer et al., 2002).

As the alluvial fans slope southeastward, they converge with the southern Yolo flood basin and marsh. Due to the gentle slopes of the fans, the boundaries between the alluvial fan, the flood basin, and the marsh are gradational and locally diffuse (Figures 2 and 4). This is especially true during periods of high runoff when the flood basin fills with water and the distal portion of the alluvial fan is inundated by water in the flood basin. Flood basin deposits in the southern part of the study area may be affected by tidal fluctuations and historical salinity intrusion (U.S. Geological Survey, 2000).

The transition from the flood basin environment southeastward to the Delta's tidal marshes is also gradational, both topographically at the surface and within deposits in the shallow subsurface. Organic matter content of the deposits increases moving southeastward as elevation decreases towards sea level (Atwater, 1982). For example, in the southeastern corner of the Study Area along Lindsey Slough and Cache Slough, Atwater (1982) described increasing thicknesses of mud and peaty mud, with up to 31.4 ft of mid- to late-Holocene peat and peaty mud at the surface. Whereas significant thicknesses of organic deposits are present along the sloughs within the West Delta Study Area, most sloughs are lacking well-developed sandy natural levee deposits like those along sloughs further east such as Miner Slough and Steamboat Slough (Atwater, 1982; FWLA, 2010). The geomorphic assessment for the nearby lower Sacramento River area contains a thorough discussion of the history of the Sacramento-San Joaquin Delta and the development of natural levee and peaty deposits found there.[3]

SURFICIAL GEOLOGIC MAPPING

Previous geologic mapping in the West Delta Study Area was completed by Helley and Harwood (1985) at a regional scale (1:62,500) and Atwater (1982) at 1:24,000 scale. The current analysis

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[3] Please see *Level 2-II Geomorphic Assessment and Surficial Mapping Along a Portion of the Sacramento River and Three Sloughs South of Courtland Study Area*; July 21, 2010; Prepared by FWLA for URS

uses this geologic framework as a basis for more detailed mapping of Quaternary deposits and geomorphic features (Plate 1). This study subdivides and delineates additional individual deposits based on relative age and depositional process or environment. Geologic units and geomorphologic features were differentiated on the basis of cross-cutting relationships with other map units, the relative degree of geomorphic expression and/or dissection with respect to similar map units, and geomorphic surface expression reflected in the historical photography and early and modern topographic maps. Primary geomorphic features and associated surficial geologic deposits, such as alluvial fans, inset channels, late Pleistocene alluvium, tidal sloughs, and Holocene through historical flood deposits, are identified (e.g., Saucier, 1994).

The surficial geologic map units within the West Delta Study Area are described below, in order from oldest to youngest.

Late-Pleistocene Map Units

The oldest geologic unit within the West Delta Study Area occurs as isolated alluvial fan remnants that occupy relatively higher-standing positions with respect to the surrounding younger flood basin and alluvial fan deposits (map unit Pf, Plate 1). These fan remnants were mapped as the upper member of the Pleistocene Modesto Formation by Helley and Harwood (1985). Given the lack of direct stratigraphic and geomorphic links between these deposits and type sections of the Modesto Formation deposits on the east side of the Sacramento River (Marchand and Allwardt, 1981), we agree with Atwater's (1981) more general "older" alluvium age and recognize them as late Pleistocene alluvial fan deposits (map unit Pf, Plate 1). Well-developed soil horizons with the associated San Ysidro Sandy Loam support this age assignment (Bates et al., 1977). These deposits likely consist of semi-consolidated silt, sand, sandy clay, and fine to coarse subrounded gravels. Map unit Pf(m) denotes the location of late Pleistocene alluvial fan deposits derived from erosion of the nearby Montezuma Hills and Coast Range foothills located to the south and west of the Study Area, respectively (Atwater, 1982; Graymer et al., 2002). These fan deposits are closer to their source areas and may be slightly sandier than adjacent late Pleistocene and Holocene alluvial fans located to the north. Areas mapped as Pf(m) have thick, clay-rich subsoils such as the the Antioch-San Ysidro complex, Solano loam, and San Ysidro loam (Bates et al., 1977).

Holocene Map Units

Much of the Study Area consists of Holocene deposits (Plate 1). Holocene-age features and sedimentary units have a somewhat subdued surface appearance in the aerial images compared to historical deposits (described below) and contacts between adjacent Holocene-age units are often subtle and relatively indistinct. This age classification reflects the low level of geomorphic activity for these features over last ~150 years, as interpreted from the aerial photographs.

Holocene channel deposits (Hch) consist of well-sorted sand, fine gravel, silt, and clay, partly filling channels. These channels are mapped from aerial photography and topographic maps where they appear as curvilinear topographic depressions. Holocene floodplain deposits include silty and sandy crevasse splays (Hcs) and overbank deposits (Hob) of the Sacramento River. Crevasse splay deposits are formed from breaching of artificial or natural levees and the deposition of radiating lobes of material on the floodplain via discrete distributary channels (e.g., Saucier, 1994). In contrast, overbank deposits are formed from broad overtopping of slough channel banks or natural levees and deposition from shallow sheet flow or standing water. Overbank deposits parallel some of the sinuous slough channels within the study area and over time accumulate to form natural levee landforms. Undifferentiated alluvial deposits (Ha) are mapped along some streams in the Study Area and consist of well-sorted to poorly-sorted sand, fine gravel, silt, and clay.

Holocene fine-grained alluvial fan deposits are mapped as map unit Hff. These deposits of silty clays with minor sands were deposited at the distal end of alluvial fan surfaces. Slope is generally less than 0.1° in these areas, and contacts between the alluvial fan deposits (Hff) and basin (Hn) and marsh deposits (Hs) are gradational. Soils developed on Holocene alluvial fan, fine facies deposits are rich in clay, inherited from the distal alluvial fan deposits in which they formed. Soils mapped on these deposits by Bates et al. (1977) include the Capay clay, Capay silty clay loam, and Clear Lake clay.

Holocene basin deposits are divided in two units: basin (Hs) and marsh (Hn). Deposition in the basins or marshes may also have occurred historically (since 1849) but the bulk of the deposits probably pre-date historic times. Basin deposits include clay and silty clay with lesser sand deposited by low-energy floodwaters that seasonally occupy the flood basin. Soils developed on flood basin deposits are clays and silty clays, with minor accumulations of alkali or lime in the subsoil, and mottling and gleying indicative of seasonally saturated conditions. Soils associated with these deposits are the Sacramento clay, Clear Lake clay, Omni silty clay, and Willows clay (Bates et al., 1972).

Holocene marsh deposits are silt and clay, sometimes organic-rich, deposited in perennially or seasonally submerged, low-lying areas. The boundary of the marsh deposits is delineated from historical topographic maps surveyed in 1906 and 1907 (Table 1b). Prior to clearing and draining of the land for agriculture, these areas were generally saturated and often thick with tule or bulrush vegetation in the latest Holocene environment (Vaught, 2006). Early topographic maps indicate marsh areas with a blue bush-like symbol, denoting a wetland with thick vegetation – a characteristic of the prehistorical Yolo Basin. Slough channels (Hsl) traverse the lowest areas of the flood basin near sea level and are tidally influenced. These low-slope and usually low-energy perennial channels carry sandy silts and clays.

Holocene peat and muck deposits (Hpm) are tidal marsh deposits that were originally more organic-rich and less consolidated that Holocene marsh deposits (map unit Hs). Holocene peat and muck deposits are typically at or below sea level and were typically enclosed by levees and drained for farming before 1937. In the island interiors they have been highly impacted by aeration, decomposition, compaction, burning, and erosion. Because of the extensive draining of the surficial peaty deposits for cultivation, as well as subsequent farming practices, much of the original surficial geologic and geomorphic character of the former tidal wetland was destroyed as of 1937. Therefore, mapping the surficial extent of unit Hpm for this study draws on existing interpretations by Atwater (1982). Within the study area, peat and muck deposits usually coincide with areas mapped as the Egbert silty clay loam and the Sacramento clay (Bates et al., 1977).

Historical Map Units

Historical deposits mapped in the West Delta Study Area include channel and floodplain deposits and artificial fill (Plate 1). The term “historical” denotes deposits laid down since 1849; historical deposits are indicated with an “R” map unit symbol. Historical deposits are differentiated from older deposits based on several criteria that are not mutually exclusive or inclusive: (1) presence of bare or slightly bare soil shown as strong tonal brightness on the air photos, indicating the deposit has not has sufficient time for substantial vegetation establishment; (2) association with soils having very little horizon development, suggesting youthful deposition; (3) active channels shown on historical topographic maps; and (4) geomorphic expression on air photos, for example: well-defined distributary channels that suggest recency of scouring flow or lack of substantial modification from cultivation processes. Historical deposits are mapped where inferred to be at least about 3 feet thick. Historical deposits include crevasse splay and overbank deposits near the river (map units Rcs and Rob), and channel and slough deposits (Rch and Rsl).

Within the topographic lows on the alluvial fan, surface water may collect to form intermittent lakes (Ril). These seasonally submerged, low-lying areas are delineated from historical topographic maps or by the distinct topographic depression and lack of marsh vegetation visible in the historical aerial photographs. Deposits within these settings are probably fine-grained, predominately silt and clay, with some sand.

Historical artificial fills are anthropogenic heterogeneous deposits with varying amounts of clay, silt, sand, and gravel from local borrow area sources. Within the West Delta Study Area, these deposits include levee structures (map unit L) and spoils from the excavation of canals (map unit AF).

CONCEPTUAL GEOMORPHIC MODEL

A conceptual model of the geologic and geomorphic setting of the study area has been developed based on synthesis of surficial geologic and geomorphic mapping, early topographic maps, soil surveys, geologic maps, and the draft Geotechnical Assessment Report (URS, 2010). This conceptual model describes general relationships among surface and subsurface geologic deposits in the West Delta Study Area (Figure 4). The model also provides a consistent framework for understanding the types and distribution of surficial geologic deposits, primary geomorphic processes, and the shallow subsurface stratigraphy of the study area.

Overall, Figure 4 presents a model in which the regional land surface slopes gently to the southeast and deposits transition laterally from mineral alluvial soils (sand, silt, and clay) above sea level in the northwest to organic-rich soils (peat and muck) below sea level in the southeast. This change is expected to be gradual across several tens to hundreds of feet and may also involve interfingering of deposits from adjacent geomorphic environments. For example, prior to levee construction, larger creeks such as Ulatis Creek flowed out into the flood basin and deposited aprons of silty sediment within the low-lying flood basin (Plate 1). Over time, flood basin sediments accumulated on top of the prograding alluvial fans, leaving only the highest-standing ridges of alluvial fan sediments exposed (Plate 1). This alternating process also results in discontinuous lenses of basin and fan sediment in the subsurface.

Subsurface Stratigraphy

The alluvial fan environment in the northwestern and western portions of the Study Area consists of several related types of generally eastward-prograding deposits: youthful and clay-rich deposits of the distal Putah Creek alluvial fan and older deposits shed from the Montezuma Hills. The Putah Creek alluvial fan sediments consist of relatively fine-grained, weathered clastic materials eroded from the northeastern Coast Range Mountains (Wagner et al., 1981; Wagner and Bortugno, 1982). Clay-rich soils such as the Capay clay and Capay silty clay loam (Bates et al., 1977) have developed within these deposits. Older Pleistocene-aged alluvial fan deposits underlie the Holocene deposits at the surface. Occasionally, the older alluvial fan remnants poke up through the younger deposits as slightly elevated knobs (Figure 4 and Plate 1) and are associated with slightly different soil series such as the San Ysidro sandy loam (Bates et al., 1977). The older alluvial fan deposits shed from the quartz-lithic sand, silt, and pebble gravel of the Montezuma Hills lie within the southwestern margin of the study area (Atwater, 1982; Graymer et al., 2002) south of Ulatis Creek (Plate 1). These smaller alluvial fans consist of sandy loam soils with well developed clay subsoils (Antioch-San Ysidro complex and Solano soils; Bates et al., 1977).

At the distal end of the alluvial fans, the geomorphic environment transitions to the topographically level flood basin setting (the southern Yolo Basin), where the ponding of floodwaters results in slack water or shallow sheet flow deposition of silt and clay (Figure 3 and 4). Much of the area is shown as seasonal and perennial marsh on historic topographic maps (Table 1b) and probably supported dense stands of bulrush or tule vegetation. Although Plate 1 shows that many levees of the West Delta Study Area lie atop basin or marsh deposits, the low slope of the Putah Creek alluvial fan and close proximity of the levees to the distal extent of the fan (Figure 3; Plate 1) suggest that alluvial fan deposits may locally underlie the levees at shallow depths, even in the low-lying basin regions.

Organic content in the surficial deposits increases southeastward through the study area as the flood basin setting transitions to the tidally-influenced portion of the Delta that is at or below sea level (Figures 2 and 4). In these locations, organic-rich and peaty deposits exist. The sloughs in these areas are not associated with well developed natural levees and thick overbank deposits. If they are present at all, the natural levee deposits are thin (Figure 4). This stands in contrast to adjacent areas within the Delta, where relatively distinct and tall natural levees have developed along the margins of the sloughs (Atwater, 1982).

APPLICATION TO STUDY AREA LEVEES

The preceding sections summarize the major map units comprising levee foundations and the shallow stratigraphic relationships in the West Delta Study Area. These factors (sediment type, permeability and shallow stratigraphic relationships) exert controls on underseepage processes.

Underseepage susceptibility analysis considers geologic deposits underlying present-day levees, the characteristics of soils developed on those deposits, and the surficial landscape features that may influence or control underseepage. The underseepage susceptibility classes in Table 2 were assigned based on geologic age, depositional environment, stratigraphic relationships, and inferred relative soil permeability. Table 2 lists the extent in miles ("mileage") and percentages of the total extent of the geologic units present beneath the subject levees of the West Delta Study Area; underseepage hazard assignments are not shown for deposits present elsewhere in the NULE Project area. Analysis results are described below.

Table 2. Underseepage Susceptibility Summary.

Unit Symbol	Unit Name	Susceptibility Rating	Mileage	Percent
Hpm	Holocene peat and muck	Very High	8.6	23.9
Rob	Historical overbank deposit	Very High	0.5	1.4
Rch	Historical channel deposits	Very High	0.1	0.3
Rcs	Historical crevasse splay deposits	Very High	0.1	0.3
W1937	Water 1937	Very High	0.1	0.3
Hs	Marsh deposits	High	13	36.1
Hob	Holocene overbank deposits	High	1.4	3.9
Rsl	Historical slough deposits	High	0.9	2.5
Hcs	Holocene crevasse splay deposits	High	0.1	0.3
Hff	Holocene fine-grained alluvial fan deposits	Moderate	3.2	8.9
Ril	Intermittent lake deposits	Moderate	0.6	1.6
Hsl	Holocene slough deposits	Moderate	0.2	0.5
Pf	Pleistocene alluvial fan deposits	Low	3.9	10.8
Hn	Holocene basin deposits	Low	3.3	9.2
Ha	Holocene alluvium	High	0.0	0.0
Hch	Holocene channel deposits	High	0.0	0.0
Pf (m)	Pleistocene alluvial fan deposits derived from the Montezuma formation	Low	0.0	0.0

Together, basin deposits and Pleistocene alluvial fan deposits underlie 7.2 miles of the subject levees within the West Delta Study Area (Table 2), primarily along upper Haas Slough, upper Cache Slough, Ulatis Creek, and Barker Slough (Plate 1). These deposits have a low susceptibility to underseepage because they either contain thick clay-rich deposits and soils (basin deposits) or they are relatively consolidated and contain relatively low permeability clayey loam subsoils due to their greater age (Pleistocene alluvial fans). The classification of these areas as low susceptibility is generally consistent with the lack of underseepage performance data presented in the draft Geotechnical Assessment Report (URS, 2010).

Four miles of levee overlie deposits having a moderate susceptibility to underseepage (Table 2). These deposits are mostly Holocene-aged fine-grained alluvial fan deposits along upper Haas slough, upper Cache Slough, and Ulatis Creek (Plate 1). Despite their fine-grained, clay-rich nature, the youthfulness of these deposits makes them less consolidated and therefore relatively more susceptible to underseepage. The draft Geotechnical Assessment Report (URS, 2010) reports no data on underseepage-related problems along the levees in these areas.

Marsh deposits underlie the largest number of miles of Project levees within the study area (Table 2: 13 miles; 36.1 percent). These deposits underlie the levees of Shag Slough, Haas Slough, Cache Slough, and Lindsey Slough in the center of the study area (Plate 1) and are highly susceptible to underseepage due to their potentially unconsolidated and organic-rich nature. Other highly susceptible deposits include the potentially sand-rich, silty Holocene crevasse splay (0.1 mi) and overbank deposits (1.4 mi) as well as Historical slough deposits (0.9 mi) (Table 2). The project levees overlie a number of Historical and Holocene-age slough channels that branch from lower Haas Slough, middle Cache Slough, and Barker Slough (Plate 1). In these locations, the channels underlying the levees were likely filled with a variety of materials dredged from the adjacent sloughs. One prominent example of extensive dredging and filling of a slough channel and the associated marsh exists where Sycamore Slough branches from lower Haas Slough (Plate 1). Although these fill materials may have been fine grained, they may also have been organic-rich and/or poorly consolidated and therefore may present a local underseepage hazard. The draft Geotechnical Assessment Report (URS, 2010) notes that the levees in the Sycamore Slough area have experienced extensive settlement and chronic slumping, consistent with the geomorphic setting and resulting fine-grained, organic and high plasticity layers.

In the southeastern portion of the study area along lower Shag, Cache, and Lindsey Sloughs, the project levees mostly overlie Holocene peat and muck and have very high susceptibilities to underseepage (Plate 1). Nearly 24 percent of the project levees sit atop these organic-rich and poorly consolidated to loose deposits (Table 2), many of which lie below sea level (Figure 2). Other localized areas estimated to be highly susceptible to underseepage include several historical crevasse splay and overbank deposits on the south bank of upper Lindsey Slough and south bank of middle Cache Slough (Plate 1) as well as several areas of former water (map unit W1937). The deposits along Lindsey Slough may relate to repeated levee breaches at that location and the deposits along Cache Slough probably relate to youthful and active tidal sloughs. In both cases, the prominence of these features displayed on the 1937 aerial photographs suggests they are some of the most youthful, unconsolidated, and possibly sandy deposits to underlie the levees in these areas. The draft Geotechnical Assessment Report (URS, 2010) does not report any underseepage performance problems in these locations. However, the report does describe several locations of boils and seepage along the northern levee Lindsey Slough levee in the area mapped as peat and muck (map unit Qpm, Plate 1).

In total, 24.8 of the 36 miles (68.9 percent) of subject levee foundations within the West Delta Study Area have high and very high susceptibilities to underseepage (Table 2). Within these 28.4 miles, future geotechnical explorations might consider collecting subsurface boring data at several specific locations to help improve the understanding of the shallow stratigraphy and foundation underseepage susceptibility. For example, a horseshoe-shaped levee on the south bank of Lindsey Slough encloses a well-developed slough channel and marsh across which the project levee was constructed. Further to the north, draft levee performance data presented in the level 2-I analysis suggest levees in the area of Sycamore Slough previously experienced failures and the Draft Geotechnical Assessment Report describes extensive settlement in the same area. For these reasons, levee foundations in the Sycamore Slough area may warrant additional geotechnical investigation. In addition, the apparently youthful and historically active slough channels and overbank deposits in the area where Hastings Cut meets Cache Slough may warrant further investigation. Additional borings in the center of the study area may provide data on the nature of the potentially complex stratigraphy resulting from interfingering of the distal alluvial fan sediments with the possibly organic-rich flood basin sediments.

SUMMARY

The West Delta Study Area is located within, and close to the western boundary of, the legally-defined Sacramento-San Joaquin Delta (State of California, 2009). Its position near the western margin of the Delta results in mineral soils from alluvial fans (sand, silt, and clay) on the west that transition southeastward to organic soils (peat) of the flood basin and central Delta (Atwater, 1982; Bates et al., 1977). The geologic contacts between the deposits (or depositional environments) typically are gradational (transitional) rather than discrete, and lateral interfingering and discontinuity of layers is likely present in the subsurface.

In the western portion of the Study Area, 7.2 miles (20 percent) of the subject levees overlie flood basin and Pleistocene alluvial fan deposits considered to have a low susceptibility to underseepage (Table 2). Four miles of levee (11 percent of total) overlie deposits having a moderate susceptibility to underseepage such as Holocene alluvial fan and slough deposits and intermittent lake deposits. In contrast, marsh deposits, Holocene crevasse splay and overbank deposits as well as Historical slough deposits are highly susceptible to underseepage due to their unconsolidated and potentially organic-rich nature. These deposits underlie 15.4 miles of the subject levees (42.8 percent), mostly along Shag Slough, Haas Slough, Cache Slough, and Lindsey Slough in the center of the study area (Plate 1). In the southeastern portion of the study area along lower Shag Slough, Cache Slough, and Lindsey Slough, the project levees mostly overlie Holocene peat and muck and are very highly susceptible to underseepage (Plate 1). Other deposits underlying the subject levees having a very high underseepage susceptibility rating include Historical crevasse splay, overbank, and channel deposits. Nearly 26.1 percent of the project levees (9.4 miles) have a very high underseepage susceptibility rating (Table 2).

LIMITATIONS

This geomorphic assessment has been performed in accordance with the standard of care commonly used as the state-of-practice in the engineering profession. Standard of care is defined as the ordinary diligence exercised by fellow practitioners in this geographic area performing the same services under similar circumstances during the same time period.

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Discussions of shallow subsurface conditions in this technical memorandum are based on interpretation of geomorphic data supplemented with very limited subsurface exploration information. Variations in subsurface conditions may exist between those shown on maps and actual conditions. Due to the scale of mapping, the project team may not be able to identify all adverse conditions in levee foundation materials.

No warranty, either express or implied, is made in the furnishing of this technical memorandum that is the result of geotechnical evaluation services. Fugro makes no warranty that actual encountered site and subsurface conditions will exactly conform to the conditions described herein, nor that this technical memorandum's interpretations and recommendations will be sufficient for construction planning aspects of the work. The design engineer or contractor should perform a sufficient number of independent explorations and tests as they believe necessary to verify subsurface conditions rather than relying solely on the information presented in this report.

Fugro does not attest to the accuracy, completeness, or reliability of maps, data sources, geotechnical borings and other subsurface data produced by others that are included in this technical memorandum. Fugro has not performed independent validation or verification of data reported by others.

Data presented in this technical memorandum are time-sensitive in that they apply only to locations and conditions that were identified at the time of preparation of this report. The maps produced generally present conditions as they occurred in the early 1900s, as primary data interpreted for this report are from this period. Data should not be applied to any other projects in or near the area of this study nor should they be applied at a future time without appropriate verification, at which point the one verifying the data takes on the responsibility for it and any liability for its use.

This technical memorandum is for the use and benefit of the California Department. of Water Resources. Use by any other party is at their own discretion and risk.

This technical memorandum should not to be used as a basis for design, construction, remedial action or major capital spending decisions.

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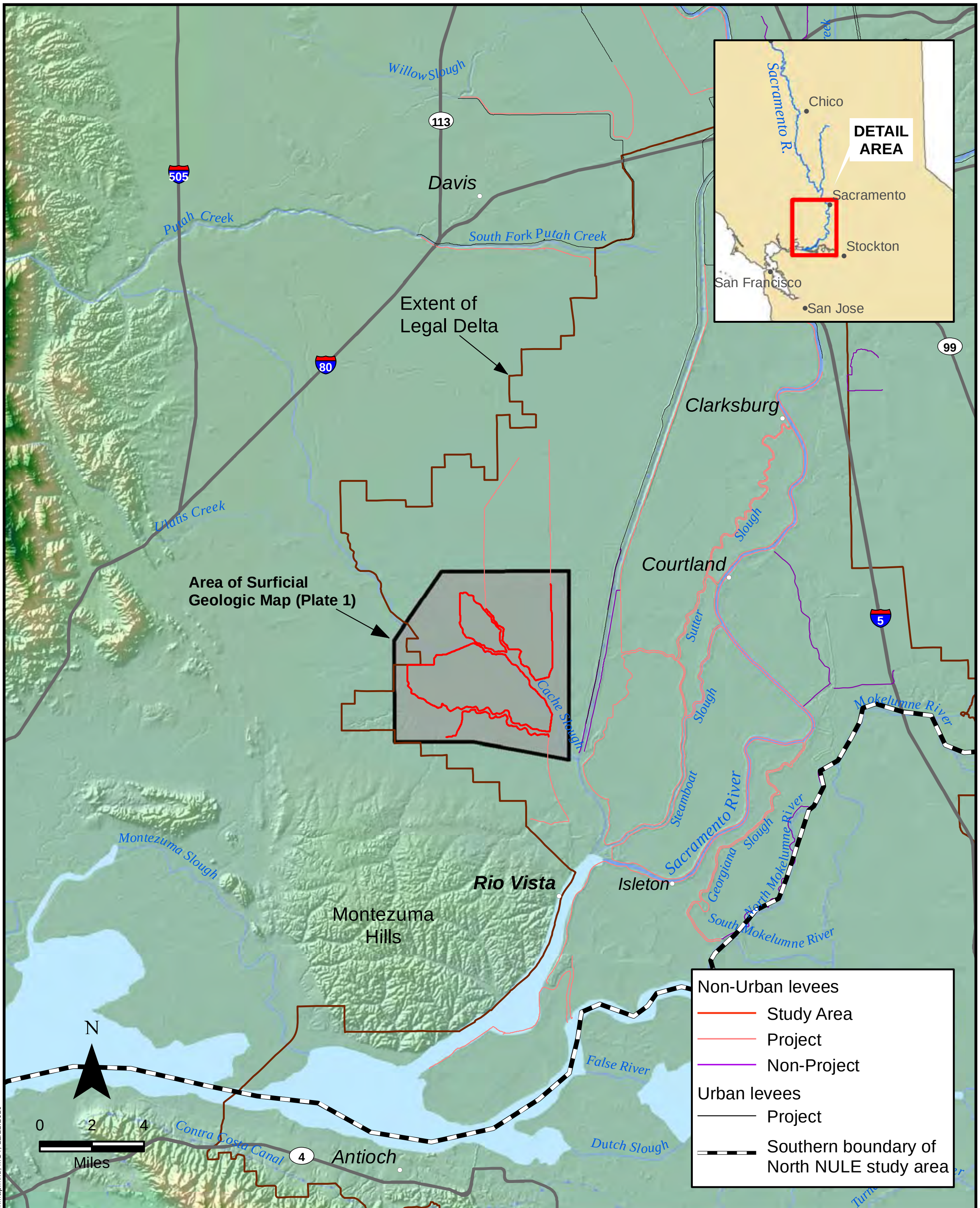
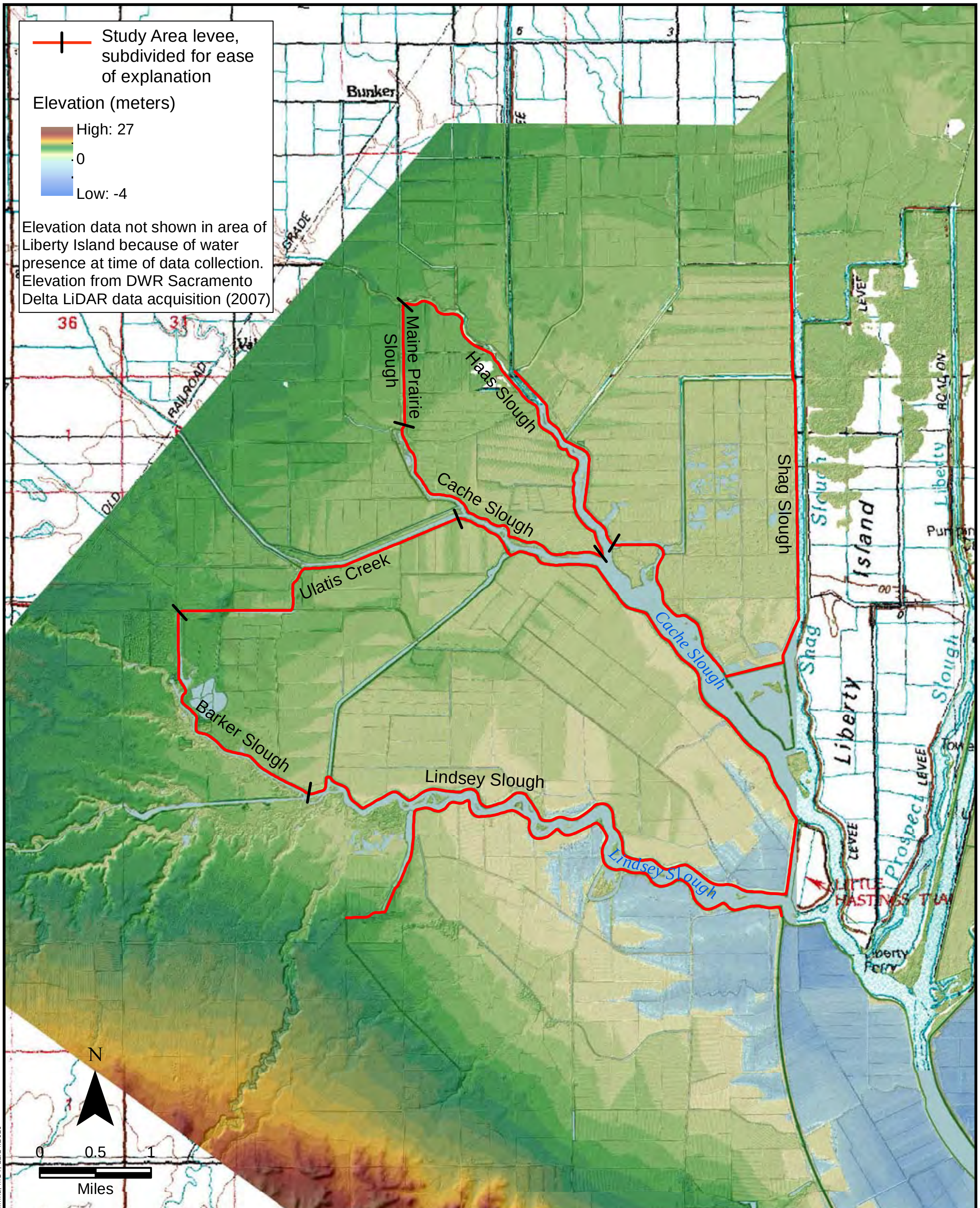


1965_2_NULE_WestDelta_LocationMap.mxd, MGT, 12/21/2010

Department of Water Resources Division of Flood Management Levee Evaluations Branch	URS in association with: Fugro WLA	Location Map NORTH NON-URBAN LEVEE EVALUATIONS	Figure 1



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Division of Flood Management
Levee Evaluations Branch

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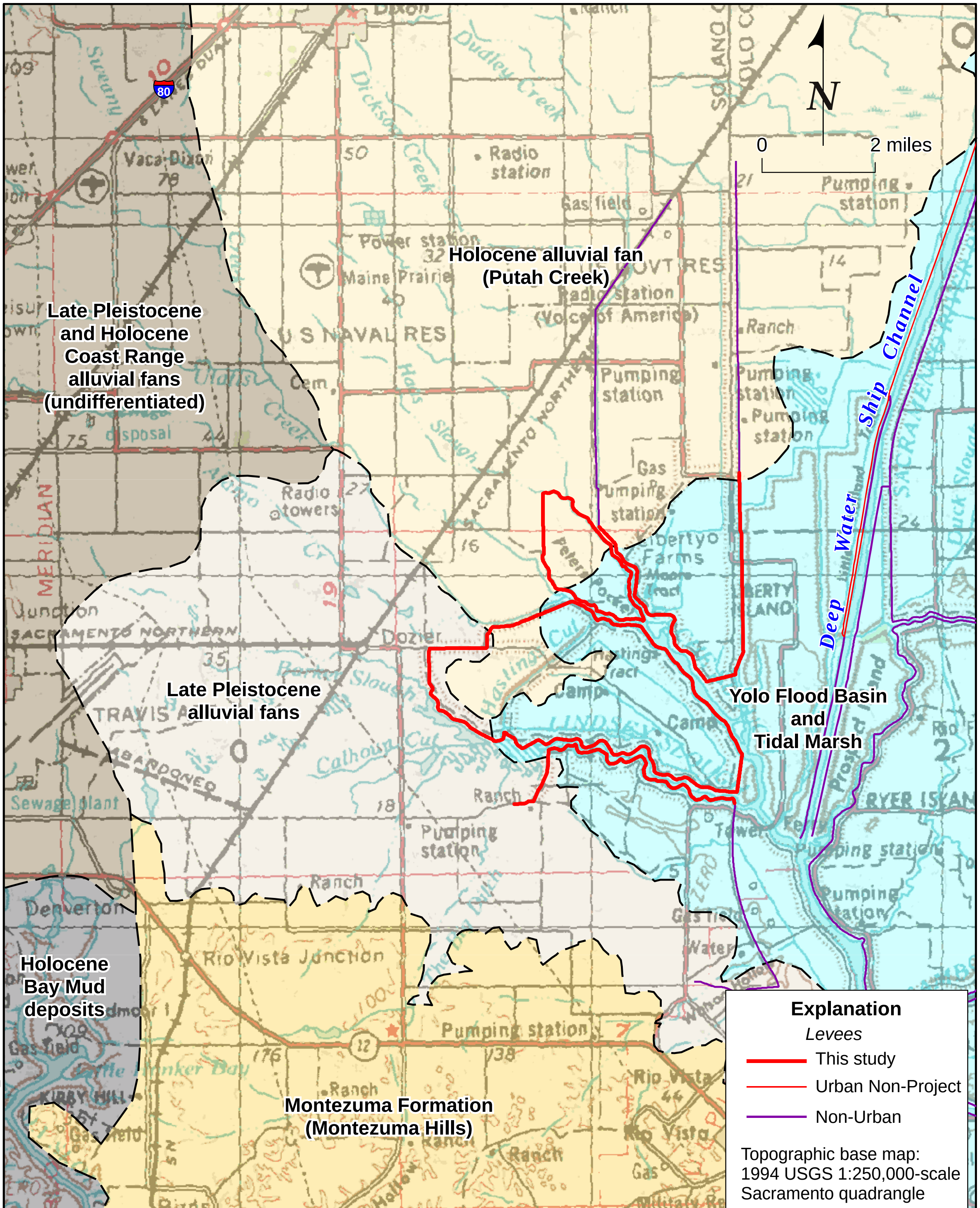
Levees of West Delta Study Area

NORTH NON-URBAN LEVEE EVALUATIONS

Figure 2

1965_2_NULE_WestDelta_Levees.mxd, MGT, 12/14/2010



GRAPHICS/1965 North Non-Urban Levees/11_West Delta/ modified 12.13.10

Department of Water Resources
Division of Flood Management
Levee Evaluations Branch

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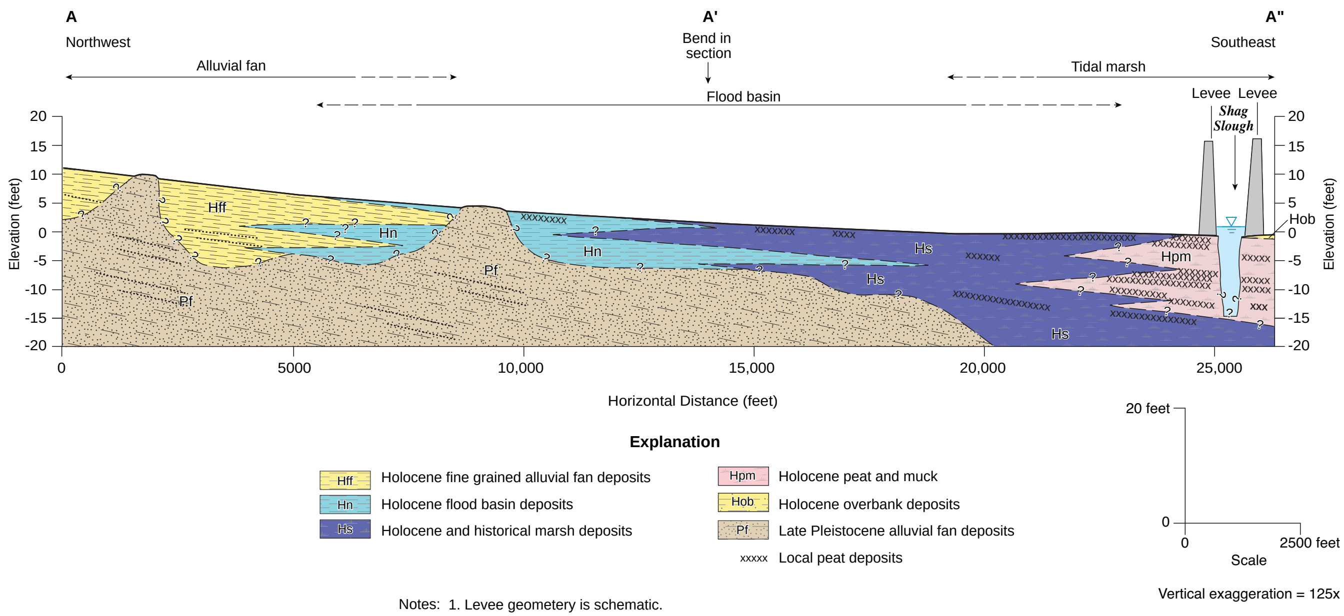
Generalized Geologic Map
of the West Delta Study Area

NORTH NON-URBAN LEVEE EVALUATIONS

Figure
3



Explanation

Hff	Holocene fine grained alluvial fan deposits
Hn	Holocene flood basin deposits
Hs	Holocene and historical marsh deposits
Hpm	Holocene peat and muck
Hob	Holocene overbank deposits
Pf	Late Pleistocene alluvial fan deposits
xxxxx	Local peat deposits

Notes:
1. Levee geometery is schematic.
2. Diagram is conceptual.
3. Natural levee deposits (Hob) thin to absent along slough.
4. Dashed contacts are approximately located; contacts queried where uncertain.
5. See Plate 1 for full unit explanations

GRAPHICS/1965 North Non-Urban Levees/11_West Delta/, modified 12.13.10

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Division of Flood Management
Levee Evaluations Branch

URS
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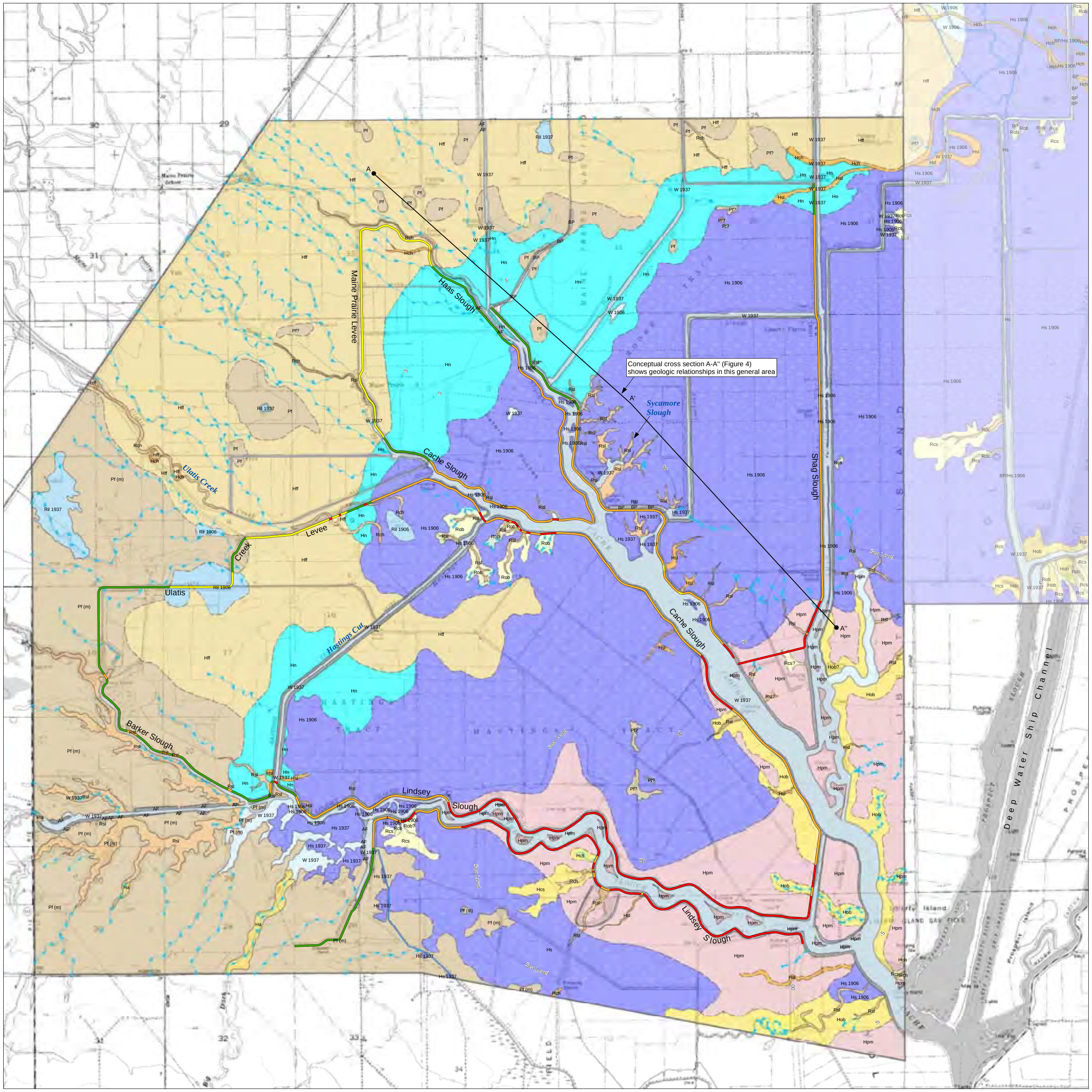
Conceptual Geologic Cross Section across West Delta Study Area

NORTH NON-URBAN LEVEE EVALUATIONS

Figure 4



This map shows surficial geologic deposits and levees as they existed in 1937. Map units and boundaries are drawn by interpretation of historical aerial photography supplemented by data from historical maps and surveys. For reference, the mapping is superimposed on modern U.S. Geological Survey 7.5' topographic base maps (individual maps referenced below).
Screened back semi-transparent mapping shown on this plate is from Deep Water Ship Channel study area, which is not assessed in this investigation. For clarity, only the surficial geologic map units of this study appear in the explanation.
See accompanying technical memorandum for complete descriptions of map units, process descriptions and methodology.
Adjacent polygons that have identical map unit symbols are employed to delineate sequences of sedimentation and landscape evolution.

Explanation

Underseepage Susceptibility Along Non-Urban Levee Alignment

Very High — High — Moderate — Low

Geologic contact; dashed where approximate, dotted where concealed, queried where uncertain. Solid contacts accurate to within 100' of line shown on map; dashed contacts accurate to within about 250' on either side of the line.

Narrow channel, generally <100 ft in width. Dashed where approximate, dotted where concealed.

Narrow, tidally influenced channel (<100 ft in width), commonly connected to a larger slough channel.

Canal

Levee; artificial fill prism, generally <70 ft in width.

Borrow pit, generally <70 ft in width.

W 1937 — Water; date indicates year of historical dataset.

BP — Borrow pit present in 1937.

Geologic Units

AF — Artificial fill, circa 1937.

L — Levee (made of artificial fill), circa 1937.

HISTORICAL

Rob — Overbank deposits; silt, sand, and lesser clay; deposited during high-stage water flow, overtopping channel banks.

Rcs — Crevasse splay deposits; fine sand and silt with clay deposited from breaching of natural or artificial levees.

Rch — Channel deposits; well sorted sand and trace fine gravel.

Rsl — Slough deposits; silt, clay, and sand, fining upward facies, low-energy channel deposits.

Ril 1906 — Intermittent lake; seasonal lake shown on historical topographic maps. Date indicates source data set.

HOLOCENE

Hob — Overbank deposits; silt, sand, and clay; deposited during high-stage water flow, overtopping channel banks.

Hcs — Crevasse splay deposits; fine sand and silt with clay deposited from breaching of natural levees.

Hff — Fine-grained alluvial fan deposits; silt and clay with sand.

Hch — Channel deposits; well sorted sand and trace fine gravel.

Hsl — Slough deposits; silt, clay, and sand, fining upward facies, low-energy channel deposits.

Ha — Alluvial deposits, undifferentiated; sand, silt, clay and minor lenses of gravel.

Hpm — Peat and muck; interbedded peat and organic-rich silt and clay, former tidal marsh deposits, mostly now leveed, drained, and farmed.

Hn — Basin deposits; fine sand, silt and clay.

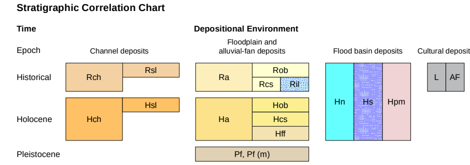
Hs 1937 — Marsh deposits; silt and clay, possibly with organic-rich beds; perennially or seasonally submerged. Date indicates year of historical dataset used to map the marsh.

PLEISTOCENE

Pf — Alluvial fan deposits; semi-consolidated silt, sand, sandy clay and fine to coarse subrounded gravel.

Pf (m) — Alluvial fan deposits of the Montezuma Hills; semi-consolidated sandy silt, sandy clayey silt, clay, sand and minor pebble gravel eroded from the early Pleistocene Montezuma Formation

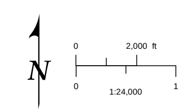
Stratigraphic Correlation Chart



Map projection: UTM NAD83 Zone 10N

Topographic base USGS 7.5' quadrangles:
Birds Landing (ID: 38121-B7), published 1953, revised 1968; map scale 1:24,000, ten foot contour interval.
Dozier (ID: 38121-C7), published 1952, revised 1968; map scale 1:24,000, five foot contour interval.
Liberty Island (ID: 38121-C6), published 1978, revised 1993; map scale 1:24,000, five foot contour interval.
Rio Vista (ID: 38121-B6), published 1978; map scale 1:24,000, five foot contour interval.

Geologic Mapping by C. Brossy
Digital Cartography by M. Ticci, R. Dulberg



Scale is 1 in = 2,000 ft when printed at 33 inch by 24 inch page size

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Surficial Geologic Map of the West Delta Study Area

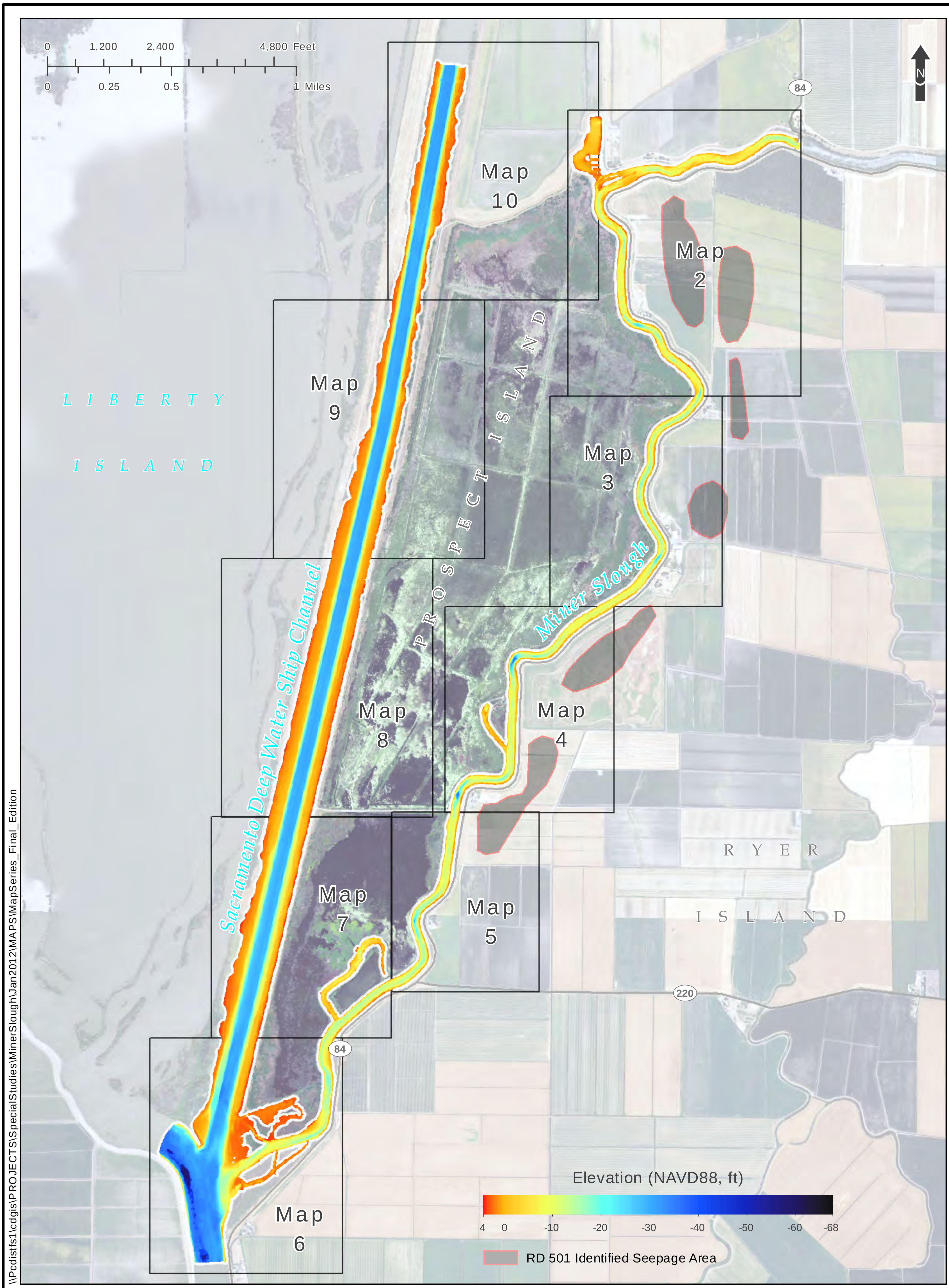
NORTH NON-URBAN LEVEE EVALUATIONS

Plate 1

DWR Levee Evaluations: Western Delta Geomorphic Assessment

1965_2_NULE_WestDelta_Plate.mxd MGT 12/14/2010

Appendix B. Miner Slough and DWSC Bathymetry



Bathymetry Near Prospect Island

January and February 2012

Map 1 of 10

STATE OF CALIFORNIA
Department of Water Resources
Division of Integrated Regional Water Management
North Central Region Office
Bathymetry and Technical Support

Survey Date: January and February 2012
Plot Date, Map Author: 3/28/12, Nicole Castagna and Amy Zuber
Collection Method: Multibeam and Singlebeam Echo Sounders
Collected by: Bathymetry and Technical Support Section
Processed by: Scott Flory, Brody Sunderland, and Wyatt Pearsall
Reviewed by: Shawn Mayr
Coordinate System: California State Plane Zone II
Projection: Lambert Conformal Conic
Datum (horizontal): NAD83
Vertical Datum: NAVD88
Unit of Measure: Feet
Surface Interpolation: Inverse Distance Weighted
Base Map: 2009 NAIP Imagery

\\pcdisfs1\Cdgis\PROJECTS\SpecialStudies\MinerSlough\Jan2012\MAPS\MapSeries_Final_Edition

Bathymetry Near Prospect Island

Map 2 of 10

Elevation (NAVD88, ft)*

4 0 -10 -20 -30 -40 -50 -60 -68

RD 501 Identified Seepage Area

Survey Date: January and February 2012
Plot Date, Map Author: 3/28/2012, Nicole Castagna and Amy Zuber
Collection Method: Multibeam and Singlebeam Echo Sounders
Coordinate System: California State Plane Zone II

*Displayed surfaces are interpolations of original data

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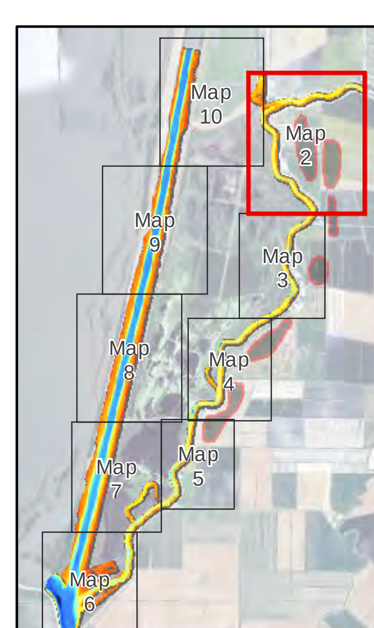

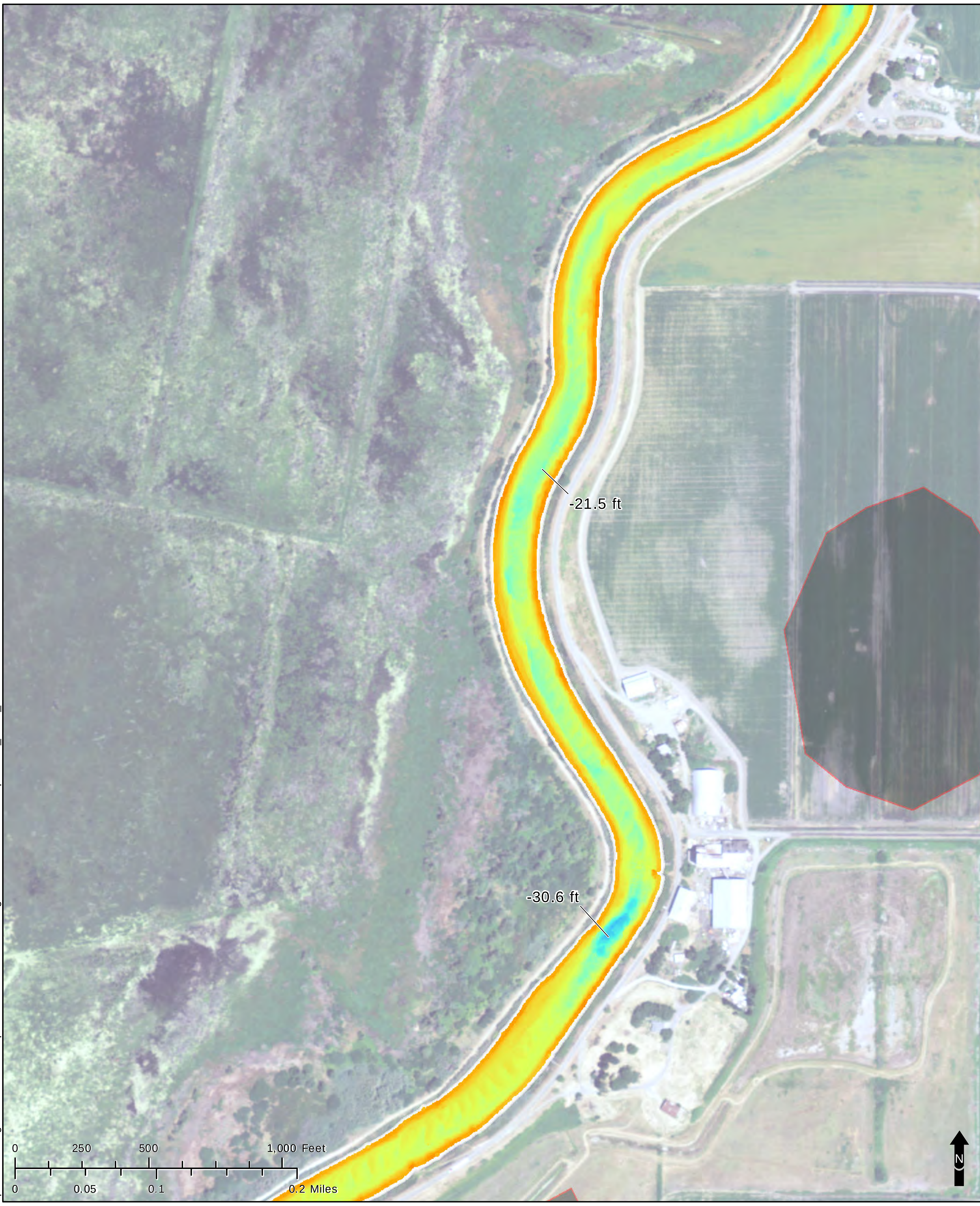

Bathymetry Near Prospect Island

Map 3 of 10

Elevation (NAVD88, ft)*

4 0 -10 -20 -30 -40 -50 -60 -68

RD 501 Identified Seepage Area

Survey Date: January and February 2012
Plot Date, Map Author: 3/28/2012, Nicole Castagna and Amy Zuber
Collection Method: Multibeam and Singlebeam Echo Sounders
Coordinate System: California State Plane Zone II

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North Central Region Office
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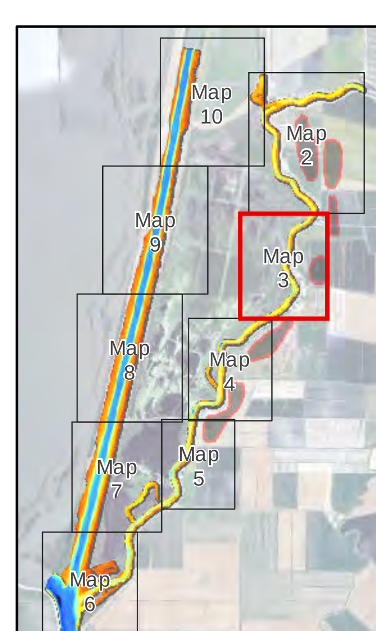

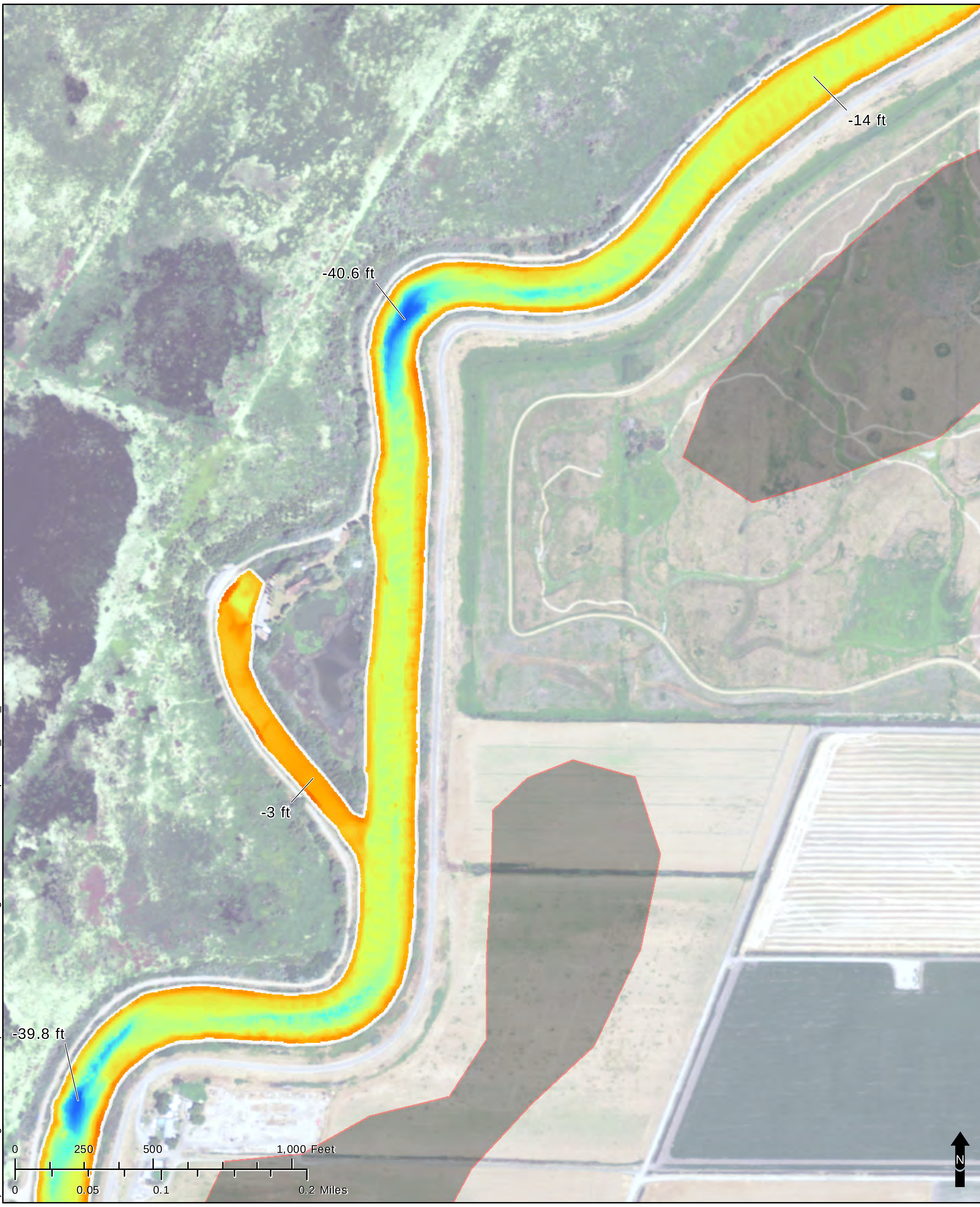

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Bathymetry Near Prospect Island

Map 4 of 10

Elevation (NAVD88, ft)*

4 0 -10 -20 -30 -40 -50 -60 -68

RD 501 Identified Seepage Area

Survey Date: January and February 2012
Plot Date, Map Author: 3/28/2012, Nicole Castagna and Amy Zuber
Collection Method: Multibeam and Singlebeam Echo Sounders
Coordinate System: California State Plane Zone II

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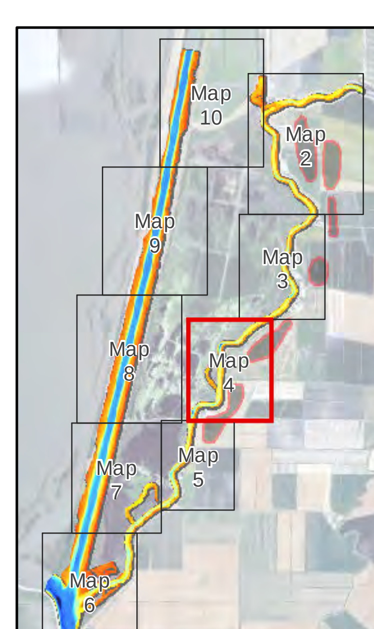

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Bathymetry Near Prospect Island

Map 5 of 10

Elevation (NAVD88, ft)*

4 | 0 | -10 | -20 | -30 | -40 | -50 | -60 | -68

RD 501 Identified Seepage Area

Survey Date: January and February 2012
Plot Date, Map Author: 3/28/2012, Nicole Castagna and Amy Zuber
Collection Method: Multibeam and Singlebeam Echo Sounders
Coordinate System: California State Plane Zone II

*Displayed surfaces are interpolations of original data

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North Central Region Office
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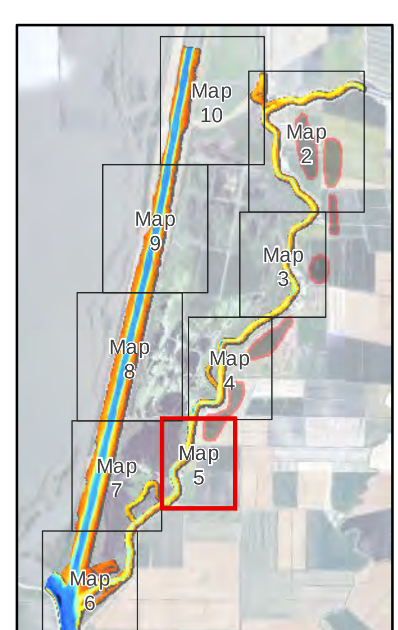

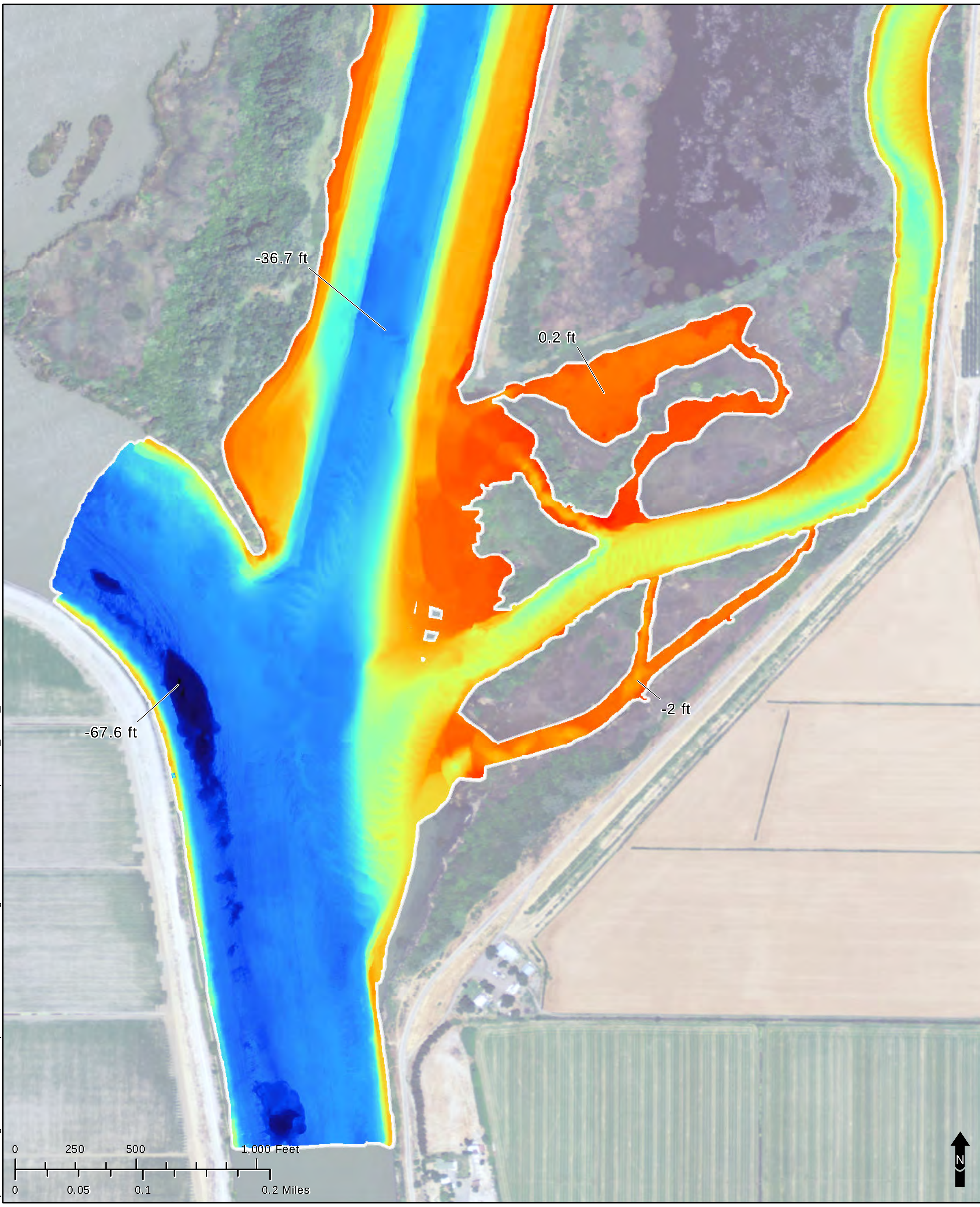

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Bathymetry Near Prospect Island

Map 6 of 10

Elevation (NAVD88, ft)*

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RD 501 Identified Seepage Area

Survey Date: January and February 2012
Plot Date, Map Author: 3/28/2012, Nicole Castagna and Amy Zuber
Collection Method: Multibeam and Singlebeam Echo Sounders
Coordinate System: California State Plane Zone II

*Displayed surfaces are interpolations of original data

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North Central Region Office
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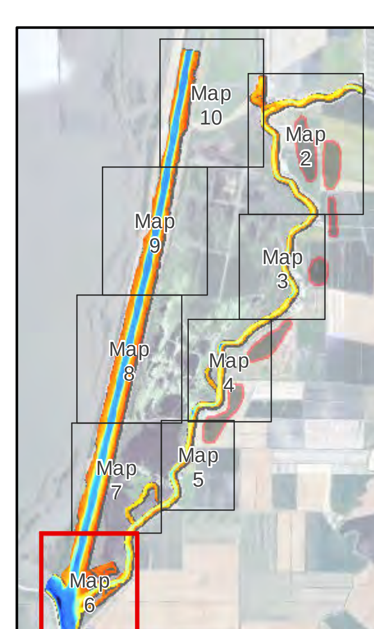

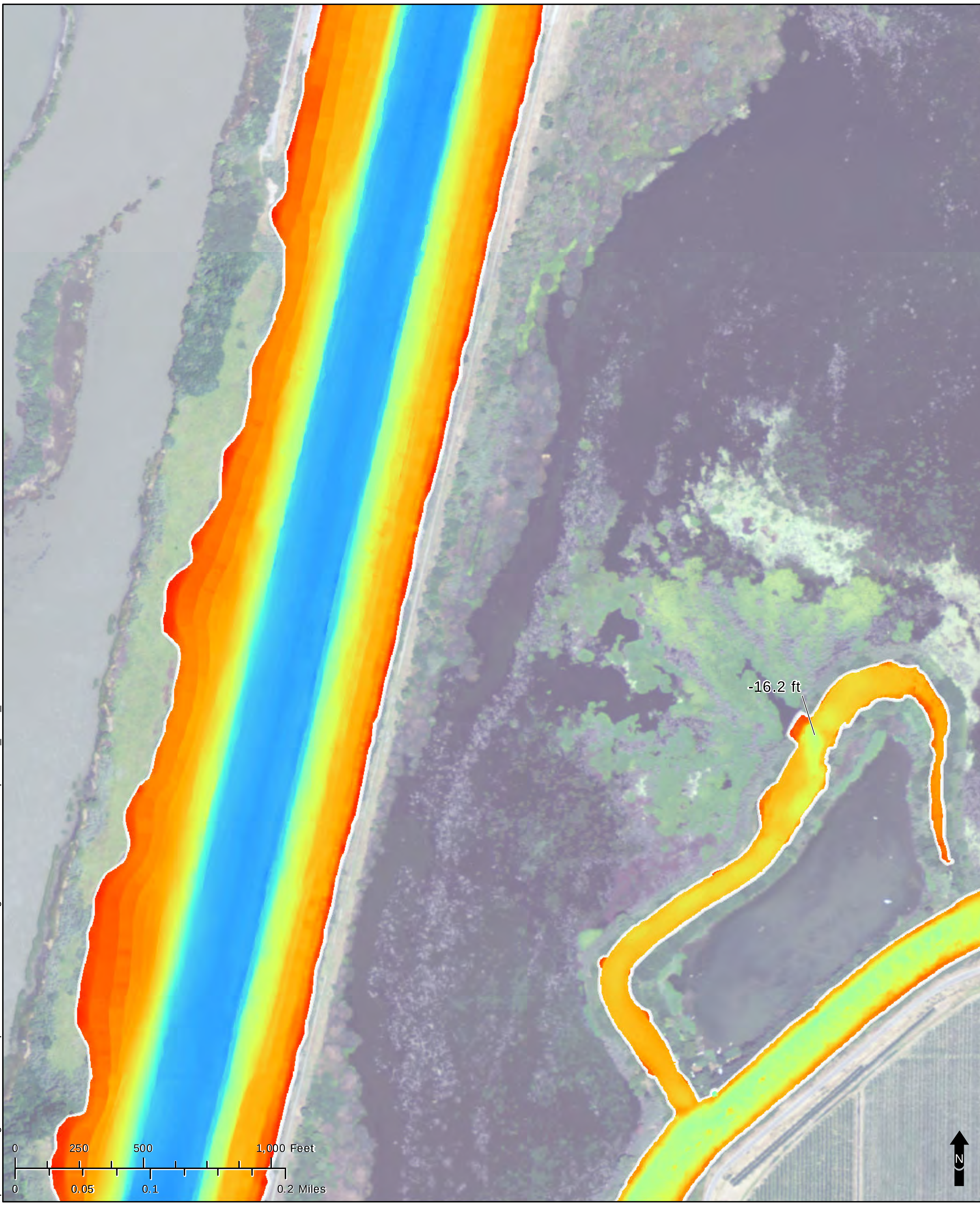

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Bathymetry Near Prospect Island

Map 7 of 10

Elevation (NAVD88, ft)*

4 0 -10 -20 -30 -40 -50 -60 -68

RD 501 Identified Seepage Area

Survey Date: January and February 2012
Plot Date, Map Author: 3/28/2012, Nicole Castagna and Amy Zuber
Collection Method: Multibeam and Singlebeam Echo Sounders
Coordinate System: California State Plane Zone II

*Displayed surfaces are interpolations of original data

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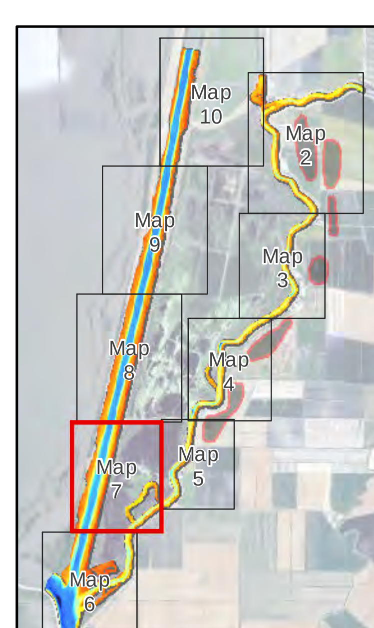
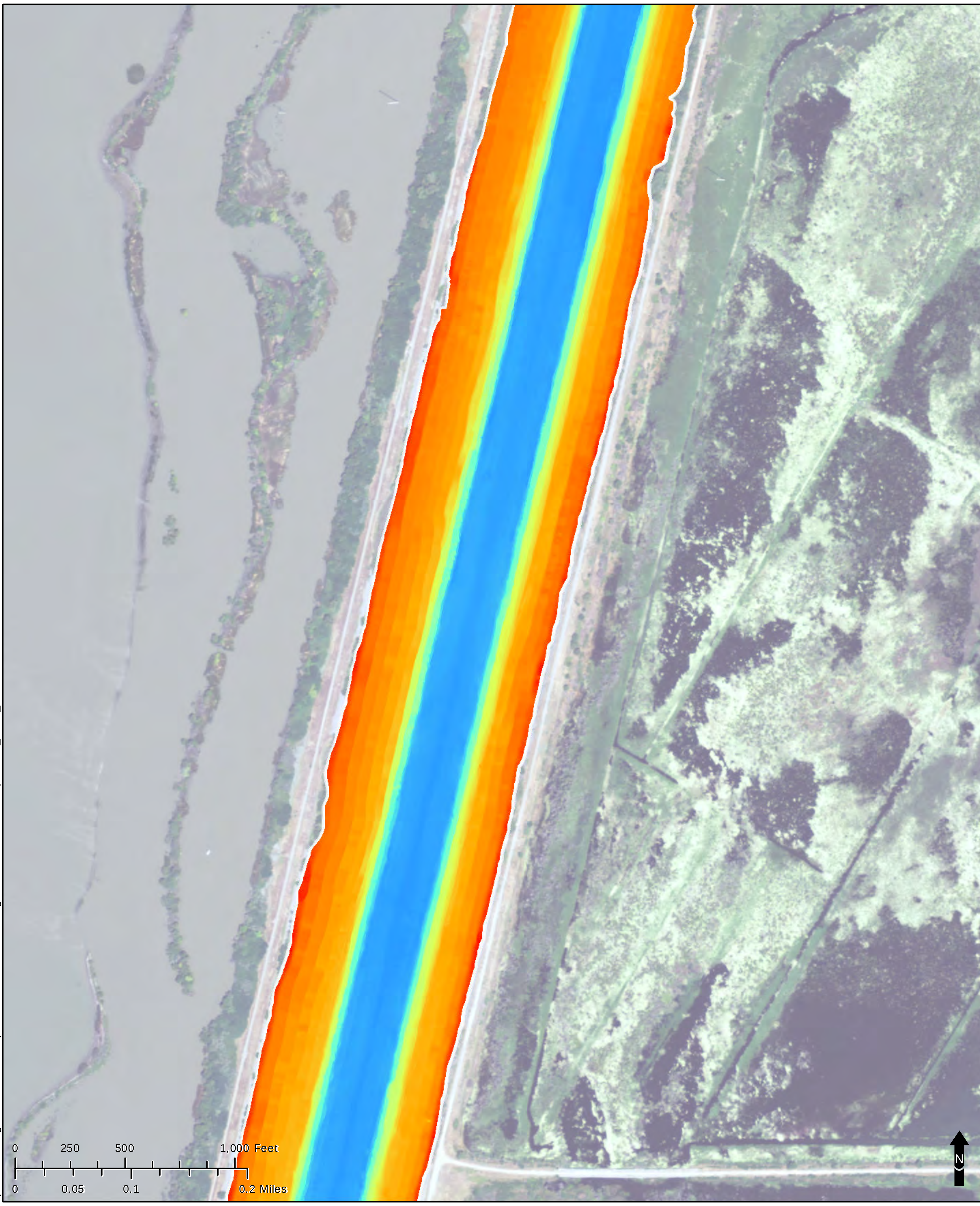
North Central Region Office
Bathymetry and Technical Support





\\pcdisfs1\Cdgis\PROJECTS\SpecialStudies\MinerSlough\Jan2012\MAPS\MapSeries_Final_Edition

Bathymetry Near Prospect Island

Map 8 of 10

Elevation (NAVD88, ft)*

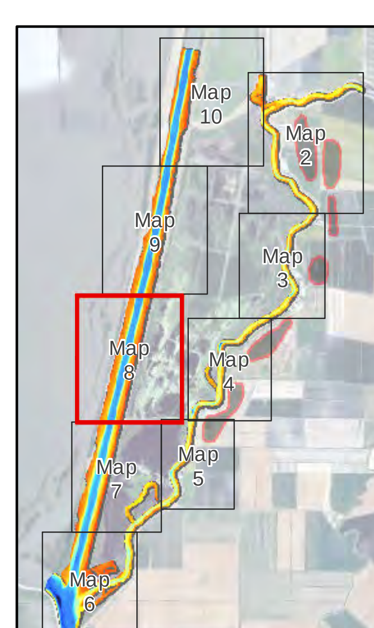
4 | 0 | -10 | -20 | -30 | -40 | -50 | -60 | -68

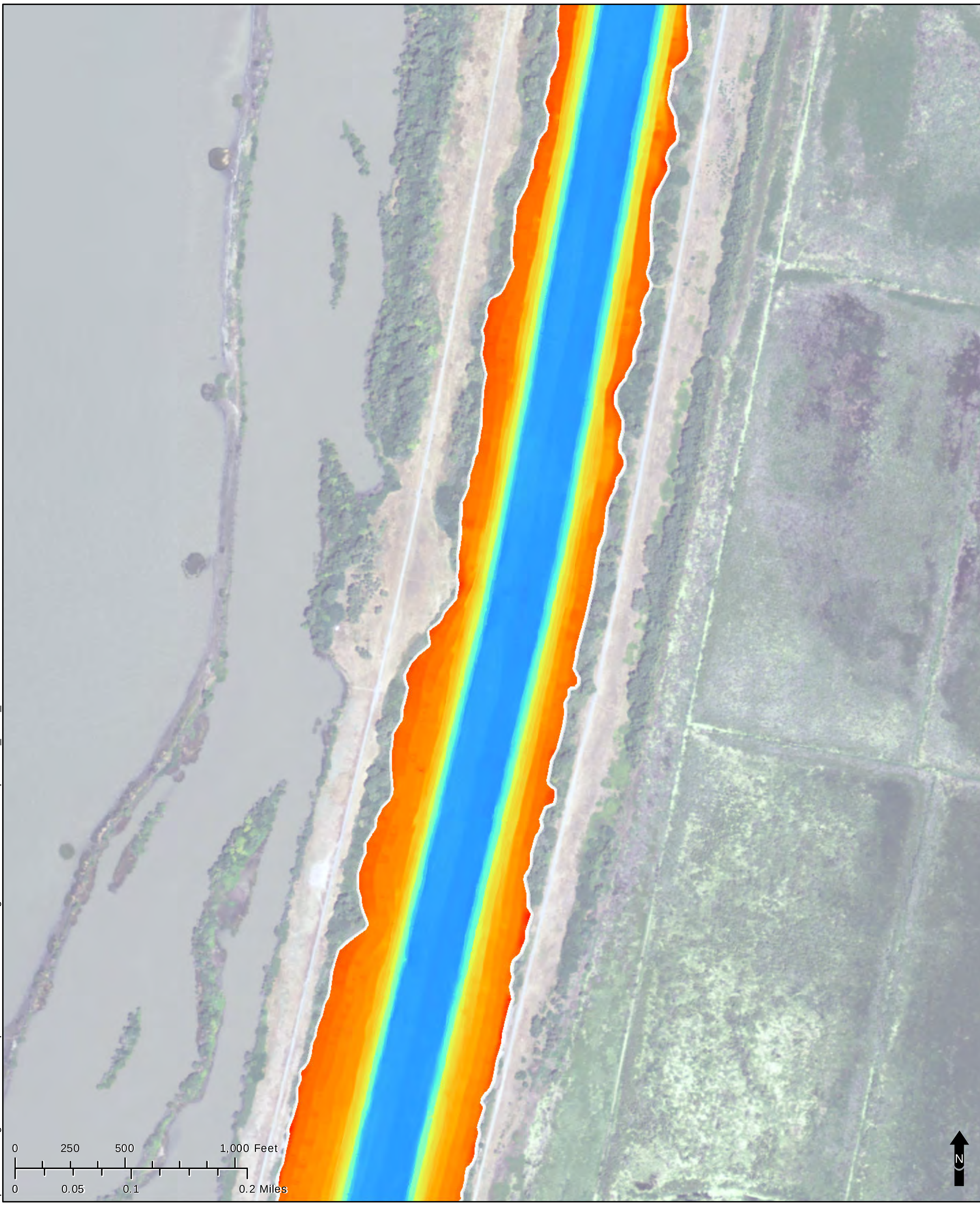
RD 501 Identified Seepage Area

Survey Date: January and February 2012
Plot Date, Map Author: 3/28/2012, Nicole Castagna and Amy Zuber
Collection Method: Multibeam and Singlebeam Echo Sounders
Coordinate System: California State Plane Zone II

*Displayed surfaces are interpolations of original data

STATE OF CALIFORNIA
Department of Water Resources
Division of Integrated Regional Water Management
North Central Region Office
Bathymetry and Technical Support





Bathymetry Near Prospect Island

Map 9 of 10

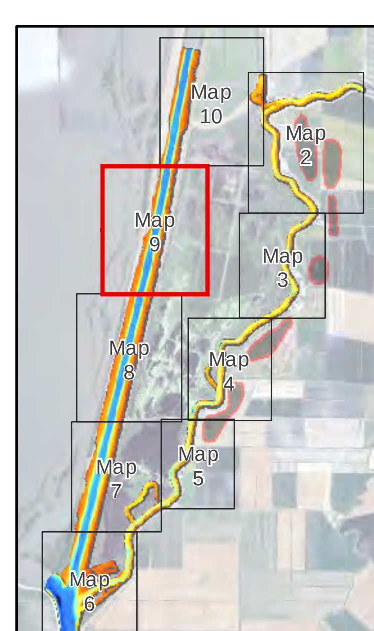
Elevation (NAVD88, ft)*

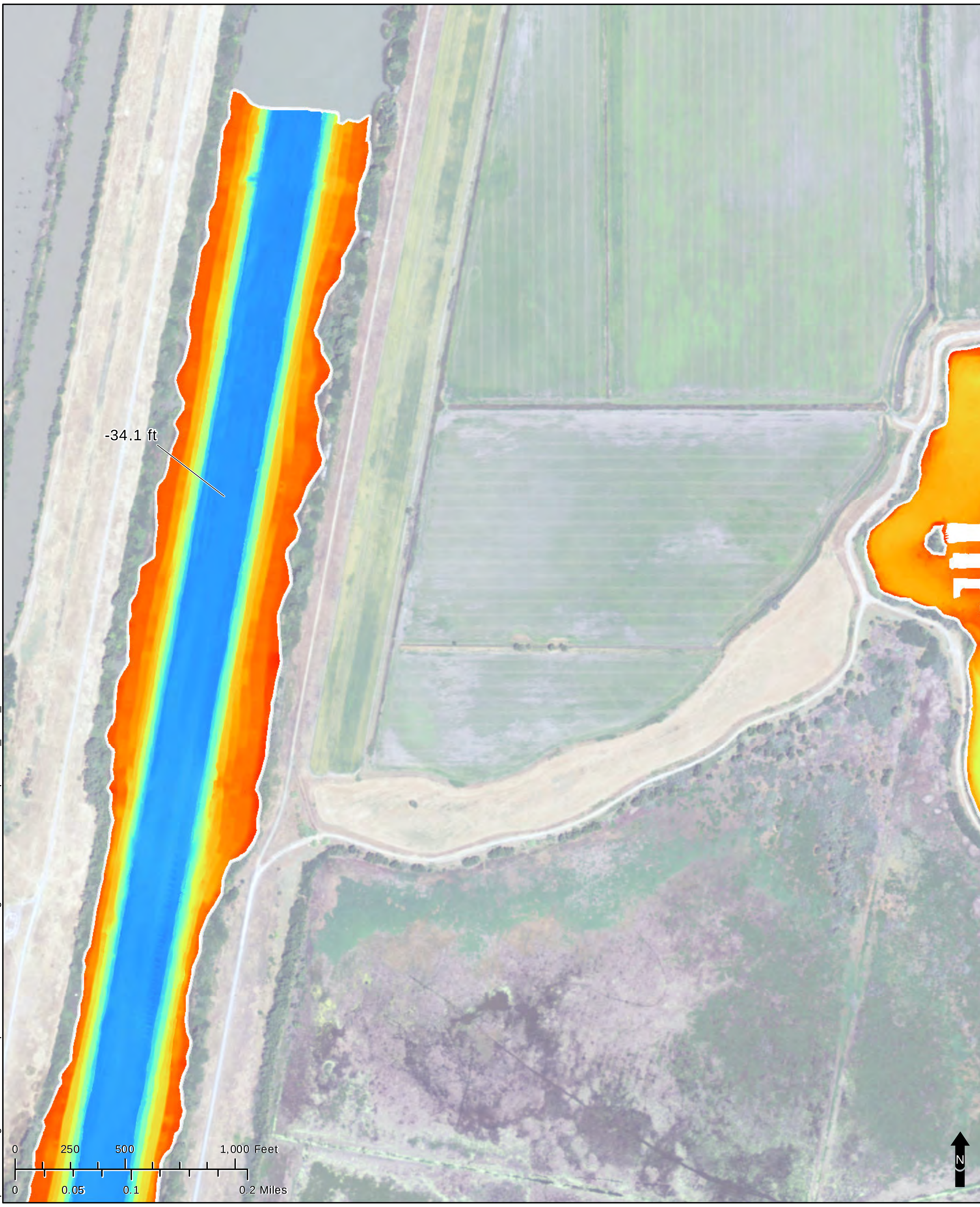
RD 501 Identified Seepage Area

Survey Date: January and February 2012
Plot Date, Map Author: 3/28/2012, Nicole Castagna and Amy Zuber
Collection Method: Multibeam and Singlebeam Echo Sounders
Coordinate System: California State Plane Zone II

*Displayed surfaces are interpolations of original data

STATE OF CALIFORNIA
Department of Water Resources
Division of Integrated Regional Water Management
North Central Region Office
Bathymetry and Technical Support





\\pcdisfs1\Cdgis\PROJECTS\SpecialStudies\MinerSlough\Jan2012\MAPS\MapSeries_Final_Edition

Bathymetry Near Prospect Island

Map 10 of 10

Elevation (NAVD88, ft)*

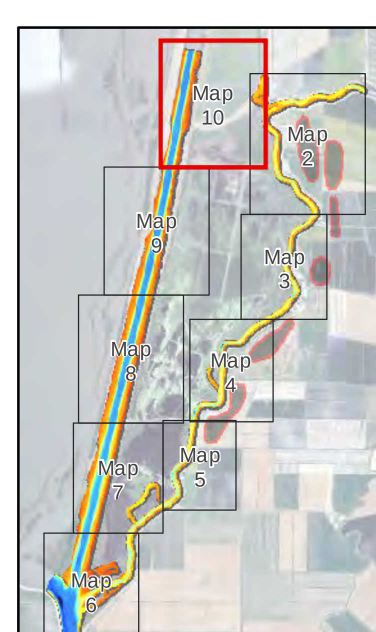
4 0 -10 -20 -30 -40 -50 -60 -68

RD 501 Identified Seepage Area

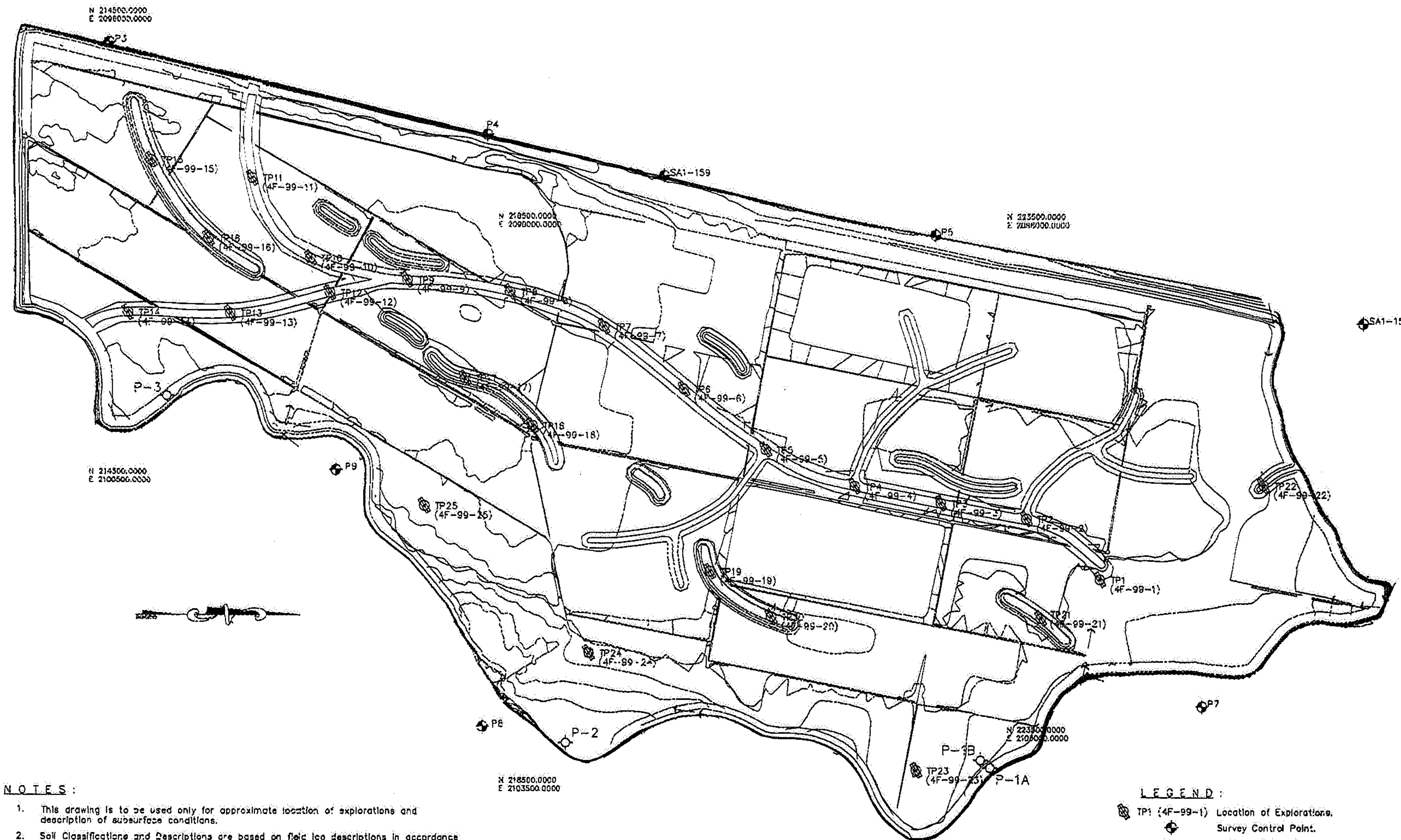
Survey Date: January and February 2012
Plot Date, Map Author: 3/28/2012, Nicole Castagna and Amy Zuber
Collection Method: Multibeam and Singlebeam Echo Sounders
Coordinate System: California State Plane Zone II

*Displayed surfaces are interpolations of original data

STATE OF CALIFORNIA
Department of Water Resources
Division of Integrated Regional Water Management
North Central Region Office
Bathymetry and Technical Support



Appendix C. USACE Trench Logs



N O T E S :

1. This drawing is to be used only for approximate location of explorations and description of subsurface conditions.
2. Soil Classifications and Descriptions are based on field log descriptions in accordance with ASTM D2488 (Description and Identification of Soils, Visual-Manual Procedure).
3. Trenches TP1 (4F-99-1) through TP21 (-21) were excavated with a John Deere 690D-LC backhoe during 20 through 22 September 1999.
4. Groundwater was encountered. Groundwater levels can be expected to fluctuate in response to rainfall and tidal Variations, particularly in the vicinity of site drainage features. Stabilized ground water elevation is expected to be near mean sea level.
5. Upper clay layers often fissured with insitu-undisturbed permeabilities greater than soil description indicates.
6. The soil encountered will be unstable. The probability of unstable conditions is highest when the soil moisture is greatest.
7. Trenches initially located by survey, then field adjusted during the exploration work. Elevations estimated/interpolated from existing survey data.
8. Site access locations are shown on sheet no. C7.0.
9. Logs of explorations are shown on sheet nos. B1.1 through B1.10.

L E G E N D :

- TP1 (4F-99-1) Location of Explorations.
- Survey Control Point.
- B.O.T. Bottom of Trench.
- Stabilized ground water level.
- 4.0' Water level / flow observed at the time of excavation.
- P-1A Location of Observation Well by Bureau of Reclamation.

GRAPHIC SCALE

500 0 250 1000 500 2000

(IN FEET)
1 inch = 500 ft.

US Army Corps of Engineers
Sacramento District

Designed by: M. Ramalathan	Date:	Rev
Dwn by: R.I.T. / Spec No.: 1124	Design file no: 52-25-400	
Reviewed by: M. Ramalathan	Drawing Code:	
Submitted by: /s/ David A. Ricketts	File name:	

DEPARTMENT OF THE ARMY
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SACRAMENTO, CALIFORNIA

SACRAMENTO DISTRICT
GEOTECHNICAL BR., IN-HOUSE DESIGN
1325 'J' STREET
SACRAMENTO, CA 95814-2922

SOLANO COUNTY CALIFORNIA
PROSPECT ISLAND RESTORATION PROJECT
PH 1 & PH 2: CONSTRUCTION & REVEGETATION

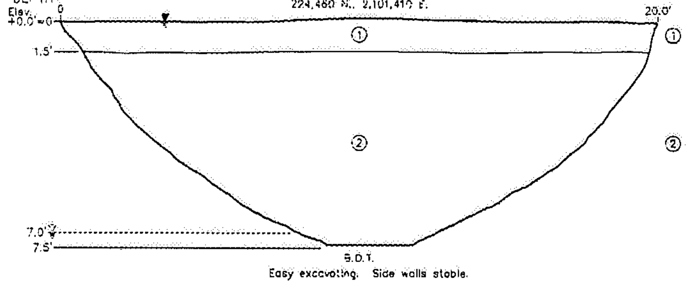
LOCATION OF EXPLORATIONS
TP1 (4F-99-1) THROUGH TP25 (4F-99-25)
AND OBSERVATION WELLS P-1A, -1B, -2 AND -3

Sheet reference number:
B1.0
Sheet of

Reference - Exploration Log file no: Soil Design Section Sheet No.

TP1 (4F-99-1)

224,460 N., 2,101,410 E.



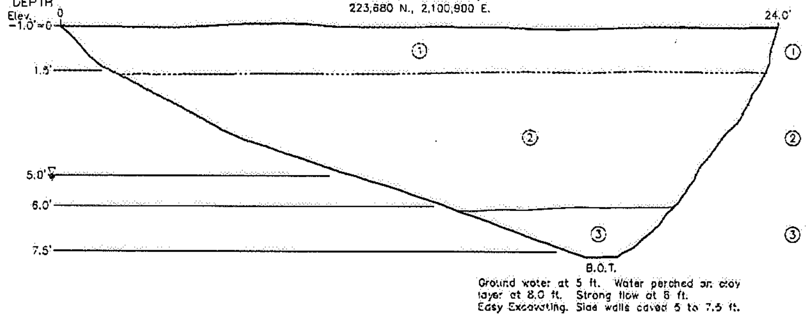
Dense vegetation at the surface

① Topsoil
<u>BORDERLINE LEAN CLAY (CL) / FAT CLAY (CH)</u>: Dry to Moist; Black; 90% Medium to High Plasticity Fines; 10% Fine Sand. Some Organic Matter (Roots)

Alluvium
② <u>LEAN CLAY (CL) AND FAT CLAY (CH)</u>: Stiff to Very Soft; Moist to Wet; Layered Black and Tan; 90% Medium to High Plasticity Fines; 10% Fine Sand. Material is Soft to Very Soft below 3.0 ft.

TP2 (4F-99-2)

223,880 N., 2,100,900 E.



Sparse grassy vegetation at surface.

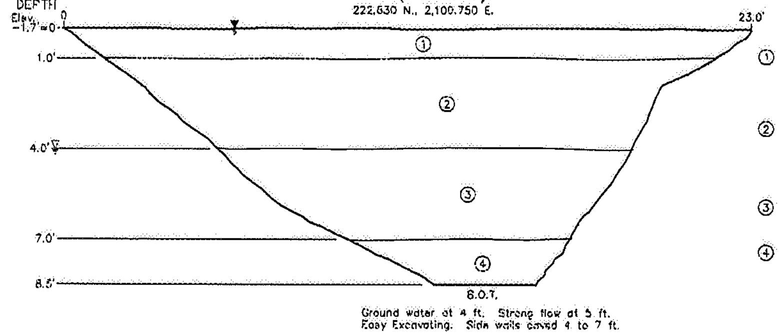
① Topsoil
<u>BORDERLINE LEAN CLAY (CL) / FAT CLAY (CH)</u>: Dry to Moist, Black, 90% Medium to High Plasticity Fines, 10% Fine Sand. Some Organic Matter (Roots).

Alluvium
② <u>LEAN CLAY (CL) AND FAT CLAY (CH)</u>: Stiff to Very Soft, Moist to Wet, Layered – Multi-colored Black, Tan, and Gray; 90% to 100% Medium to High Plasticity Fines; 0% to 10% Fine Sand
Material is Soft to Very Soft below 1.5 ft.

Alluvium (Possible Marine Sediment):
③ <u>FAT CLAY (CH)</u>: Very Soft to Soft, Wet, Blue Gray, 100% High Plasticity Fines.

TP3 (4F-99-3)

222,630 N., 2,100,750 E.



Sparse grassy vegetation at surface.

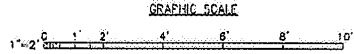
Topsoil
① <u>BORDERLINE LEAN CLAY (CL) / FAT CLAY (CH)</u>: Dry to Moist, Black, 90% Medium to High Plasticity Fines, 10% Fine Sand. Some Organic Matter (Roots).

Alluvium
② <u>LEAN CLAY (CL) AND FAT CLAY (CH)</u>: Stiff to Very Soft, Moist to Wet, Layered – Multi-colored Black, Tan, and Grey; 90% Medium to High Plasticity Fines; 10% Fine Sand
Material is Soft to Very Soft below 1.0 ft.

Alluvium
③ <u>FAT CLAY (CH)</u>: Very Soft to Soft, Wet, Dark Gray, 100% High Plasticity Fines

Alluvium
④ <u>LEAN CLAY (CL) AND FAT CLAY (CH)</u>: Soft to Very Soft; Wet; Layered – Multi-colored Black, Tan, and Grey; 90% Medium to High Plasticity Fines; 10% Fine Sand

GRAPHIC SCALE



NOTES:

1. Legend, notes, and location of explorations are shown on sheet no. B1.0.
2. Logs of explorations are shown on sheets nos. B1.1 through B1.10.

US Army Corps of Engineers
Sacramento District

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SACRAMENTO DISTRICT
GEOTECHNICAL BR. IN-HOUSE DESIGN
1325 J STREET
SACRAMENTO, CA 95814-2922

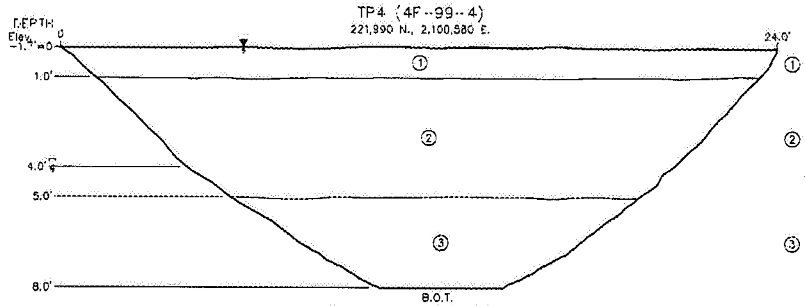
SOLANO COUNTY CALIFORNIA
PROSPECT ISLAND RESTORATION PROJECT
PH 1 & PH 2: CONSTRUCTION & REVEGETATION

LOG OF EXPLORATIONS
TP1 (4F-99-1) THROUGH TP3 (4F-99-3)

Sheet reference number:
B1.1
Sheet of

Reference – Exploration Log file no. Soil Design Section Sheet No. 2 of 11

TP4 (4F-99-4)
221,990 N., 2,100,580 E.



Ground water at 4.5ft. Water perched on clay layer at 5.0 ft.
Easy Excavating. Side walls caved 0 to 5 ft.

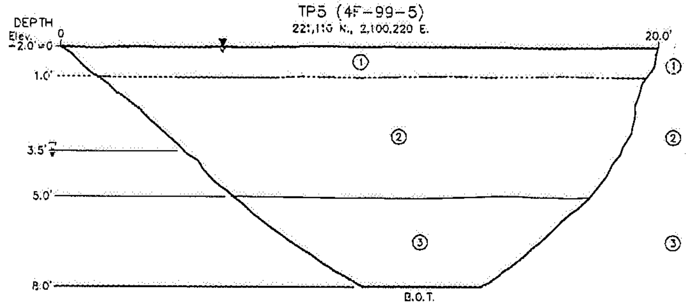
Grassy vegetation at surface.

① Topsoil
LEAN CLAY (CL): Dry to Moist; Black; 90 % Medium Plasticity Fines; 10% Fine Sand; Some Organic Matter (Roots)

② Alluvium
FAT CLAY (CH): Soft to Very Soft; Moist to Wet; Layered - Multi-colored Black, Tan, and Gray; 95% to 100% Medium to High Plasticity Fines; 0% to 5% Fine Sand

③ Alluvium (Possible Marine Sediment)
FAT CLAY (CH): Very Soft to Firm; Wet; Blue-Gray; 100% High Plasticity Fines

TP5 (4F-99-5)
221,110 N., 2,100,220 E.



Ground water at 3.5ft. Water perched on clay layer at 5.0 ft. Strong flow at 3.5 ft.
Easy Excavating. Side walls caved 0 to 5 ft.

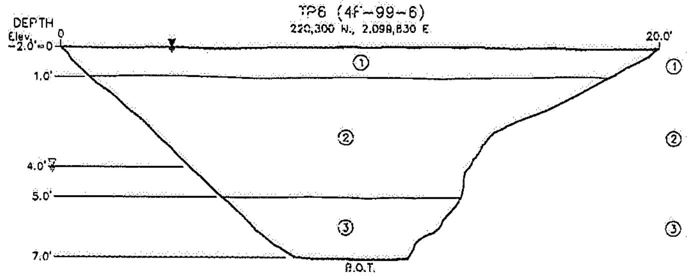
Sparse weedy vegetation at surface

① Topsoil
LEAN CLAY (CL): Dry to Moist; Black; 90% Medium Plasticity Fines; 10% Fine Sand; Some Organic Matter (Roots)

② Alluvium
LEAN CLAY (CL) AND FAT CLAY (CH): Firm to Very Soft; Moist to Wet; Layered - Multi-colored Black, Tan, and Gray; 95% to 100% Medium to High Plasticity Fines; 0 % to 5% Fine Sand
Material is Soft to Very Soft below 1.5ft.

③ Alluvium (Possible Marine Sediment)
FAT CLAY (CH): Very Soft to Firm; Wet; Blue-Gray; 100% High Plasticity Fines

TP6 (4F-99-6)
220,300 N., 2,098,830 E.



Ground water at 4.0 ft. Water perched on clay layer at 5.0 ft. Strong flow at 4.0 ft.
Easy Excavating. Side walls caved 0 to 7.0 ft.

Sparse grass and weedy vegetation at surface

① Topsoil
LEAN CLAY (CL): Dry to Moist; Black; 90% Medium Plasticity Fines; 10% Fine Sand; Some Organic Matter (Roots)

② Alluvium
LEAN CLAY (CL) AND FAT CLAY (CH): Firm to Very Soft; Moist to Wet; Layered - Multi-colored Black, Tan, and Gray; 90% to 100% Medium to High Plasticity Fines; 0% to 10% Fine Sand
Material is Soft to Very Soft below 1.0 ft.

③ Alluvium (Possible Marine Sediment)
FAT CLAY (CH): Very Soft to Firm; Wet; Blue-Gray; 100% High Plasticity Fines

GRAPHIC SCALE

1"=2' 0 1' 2' 4' 6' 8' 10'

NOTES

1. Legend, notes, and location of explorations are shown on sheet no. B1.0.
2. Logs of explorations are shown on sheet nos. B1.1 through B1.10.

US Army Corps of Engineers
Sacramento District

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1325 J STREET
SACRAMENTO, CA 95814-2922

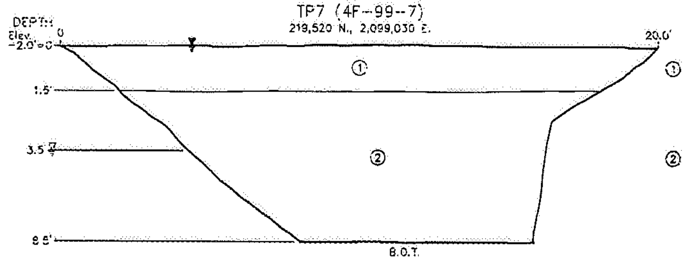
SOLANO COUNTY CALIFORNIA
PROSPECT ISLAND RESTORATION PROJECT
PH. 1 & PH. 2: CONSTRUCTION & REVEGETATION

LOG OF EXPLORATIONS
TP4 (4F-99-4) THROUGH TP6 (4F-99-6)

Sheet reference number:
B1.2
Sheet of

TP7 (4F-99-7)

219,520 N., 2,099,030 E.



Ground water at 3.5 ft. Strong flow at 3.5 ft. Easy Excavating. Side walls very unstable, caved at 0 to 6.5 ft.

Sparse vegetation at surface

Topsoil

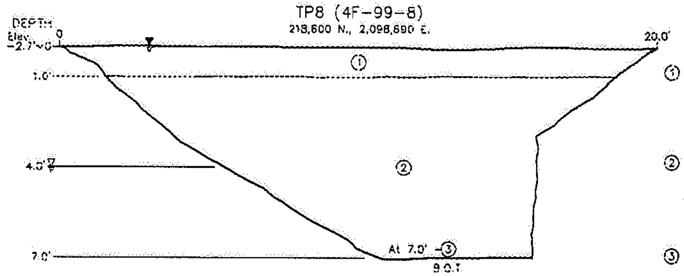
(1) LEAN CLAY (CL): Dry to Moist; Black; 90% Medium to High Plasticity Fines; 10% Fine Sand; Some Organic Matter (Roots)

Alluvium

(2) LEAN CLAY (CL) AND FAT CLAY (CH): Firm to Very Soft; Moist to Wet; Layered – Multi-colored Black, Tan, and Gray; 90% Medium to High Plasticity Fines; 10% Fine Sand. Material is Soft to Very Soft below 1.5 ft.

TP8 (4F-99-8)

218,600 N., 2,098,690 E.



Ground water at 4.0 ft. Water perched on clay layer at 7.0 ft. Moderate flow at 4.0 ft. Easy Excavating. Side walls caved at 0 to 7.0 ft.

Grass and weedy vegetation at surface

Topsoil

(1) LEAN CLAY (CL): Dry to Moist; Black; 90% Medium Plasticity Fines; 10% Fine Sand; Some Organic Matter (Roots)

Alluvium

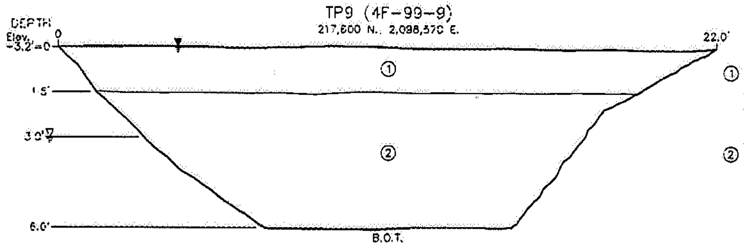
(2) LEAN CLAY (CL) AND FAT CLAY (CH): Firm to Very Soft; Moist to Wet; Layered – Multi-colored Black, Tan, and Gray; 90% Medium to High Plasticity Fines; 10% Fine to Medium Sand. Material is Soft to Very Soft below 1.0 ft.

Alluvium (Possible Marine Sediment)

(3) FAT CLAY (CH): Very Soft to Firm; Wet; Blue-Gray; 100% High Plasticity Fines

TP9 (4F-99-9)

217,600 N., 2,098,570 E.



Ground water at 3.0 ft. Moderate flow at 3.0 ft. Easy Excavating. Side walls very unstable and caved from 0 to 6.0 ft.

Thick weedy vegetation at surface

Topsoil

(1) BORDERLINE FAT CLAY (CH) / LEAN CLAY (CL): Dry to Moist; Black; 90% Medium To High Plasticity Fines; 10% Fine Sand; Some Organic Matter (Roots)

Alluvium

(2) LEAN CLAY (CL) AND FAT CLAY (CH): Stiff to Very Soft; Moist to Wet; Layered – Multi-colored Black, Tan, and Gray; 90% Medium to High Plasticity Fines; 10% Fine to Medium Sand. Material is Soft to Very Soft below 0.5 ft. Thin orange nodular mineral layer observed

GRAPHIC SCALE

1"=2' 0 1' 2' 4' 6' 8' 10'

NOTES

1. Legend, notes, and location of explorations are shown on sheet no. B1.0.
2. Logs of explorations are shown on sheet nos. B1.1 through B1.10.

US Army Corps of Engineers
Sacramento District

SOLANO COUNTY CALIFORNIA
PROSPECT ISLAND RESTORATION PROJECT
PH 1 & PH 2: CONSTRUCTION & REVEGETATION

LOG OF EXPLORATIONS
TP7 (4F-99-7) THROUGH TP9 (4F-99-9)

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

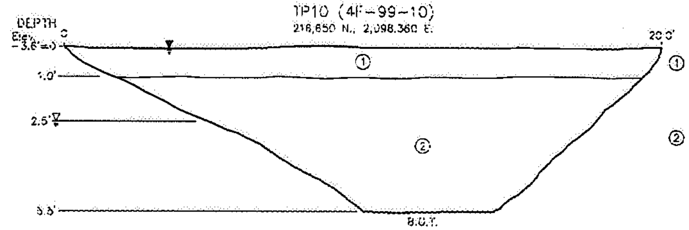
SACRAMENTO DISTRICT
GEOTECHNICAL BR., IN-HOUSE DESIGN
1325 'J' STREET
SACRAMENTO, CA 95814-2922

Designed by: M. Ramsbotham
Dwn by: M.L.T.
Spec No.: 1124
Reviewed by: M. Ramsbotham
Submitted by: /s/ David A. Rybolt...
Date:
Design file no. 02-25-400
Drawing Code:
Rev.

Sheet reference number:
B1.3
Sheet of

TP10 (4F-99-10)

216,850 N., 2,098,360 E.



Ground water at 2.5 ft. Low flow at 2.5 ft.
Easy Excavating. Side walls marginally stable.
No caving

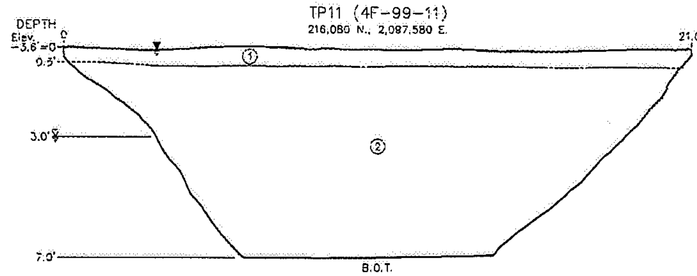
Sparse weedy vegetation at surface

① Topsoil
LEAN CLAY (CL): Dry to Moist; Black; 90% Medium Plasticity Fines; 10% Fine Sand; Some Organic Matter (Roots)

② Alluvium
LEAN CLAY (CL) AND FAT CLAY (CH): Firm to Very Soft; Moist to Wet; Layered - Multi-colored Black, Tan, and Gray; 95% Medium to High Plasticity Fines; 5% Fine to Medium Sand. Material is Soft to Very Soft below 0.5 ft. Thin orange nodular mineral layer observed at 5.0 ft. depth

TP11 (4F-99-11)

216,080 N., 2,097,580 E.



Ground water at 3.0 ft. Strong flow at 6.0 ft.
Easy Excavating. Side walls caved 0 to 7.0 ft.

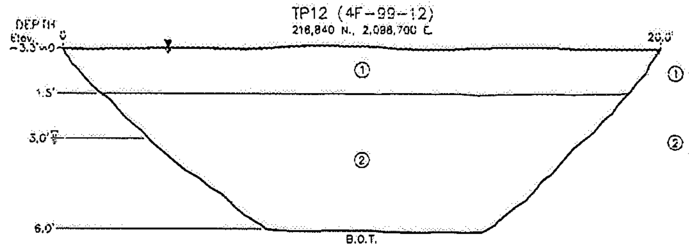
Sparse weedy vegetation at surface

① Topsoil
LEAN CLAY (CL): Dry to Moist; Black; 90% Medium Plasticity Fines; 10% Fine Sand; Some Organic Matter (Roots)

② Alluvium
LEAN CLAY (CL) AND FAT CLAY (CH): Firm to Very Soft; Moist to Wet; Layered - Multi-colored Black, Tan, and Gray; 90% Medium to High Plasticity Fines; 10% Fine to Medium Sand. Material is Soft to Very Soft below 0.5 ft. Thin orange nodular mineral layer observed at 3.0 ft. depth

TP12 (4F-99-12)

216,840 N., 2,098,700 E.



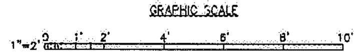
Ground water at 3.0 ft. Low flow at 5.0 ft.
Easy Excavating. Side walls stable.

Sparse weedy vegetation at surface

① Topsoil
LEAN CLAY (CL): Dry to Moist; Black; 90% Medium Plasticity Fines; 10% Fine Sand; Some Organic Matter (Roots)

② Alluvium
LEAN CLAY (CL) AND FAT CLAY (CH): Firm to Very Soft; Moist to Wet; Layered - Multi-colored Black, Tan, and Gray; 90% Medium to High Plasticity Fines; 10% Fine to Medium Sand. Material is Soft to Very Soft below 1.0 ft.

GRAPHIC SCALE



NOTES

1. Legend, notes, and location of explorations are shown on sheet no. B1.0.
2. Logs of explorations are shown on sheet nos. B1.1 through B1.9.

US Army Corps of Engineers
Sacramento District

DEPARTMENT OF THE ARMY
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SACRAMENTO, CALIFORNIA

SACRAMENTO DISTRICT
GEOTECHNICAL BR., IN-HOUSE DESIGN
1325 'J' STREET
SACRAMENTO, CA 95814-2922

Designed by: M. Ramsbotham
Dwn by: K.L.T.
Spec No.: 1124
Reviewed by: M. Ramsbotham
Submitted by: /s/ David A. Ripley
Design file no. 32-25-495

SOLANO COUNTY CALIFORNIA
PROSPECT ISLAND RESTORATION PROJECT
PH 1 & PH 2: CONSTRUCTION & REVEGETATION

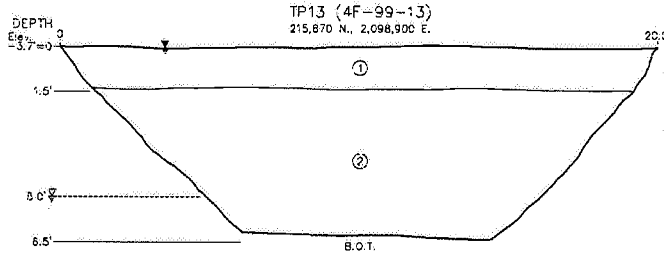
LOG OF EXPLORATIONS
TP10 (4F-99-10) THROUGH TP12 (4F-99-12)

Sheet reference number: B1.4

Reference - Exploration Log file no. 32-01-402

TP13 (4F-99-13)

215,870 N., 2,098,900 E.



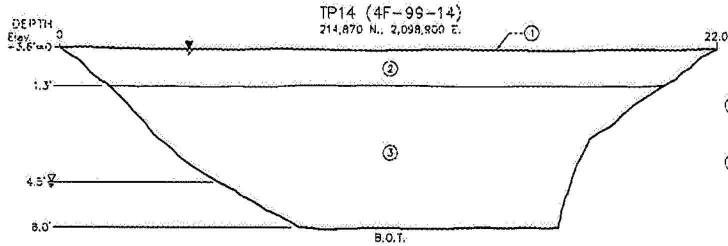
Ground water at 5.0 ft. Low flow at 5.0 ft.
Easy Excavating. Side walls stable.

Dense weedy vegetation at surface
Topsoil
① LEAN CLAY (CL): Dry to Moist; Black; 90% Medium Plasticity Fines; 10% Fine Sand; Some Organic Matter (Roots)

Alluvium (Peat)
② ORGANIC CLAY, (OH) AND FAT CLAY, (CH): Stiff to Very Soft; Moist to Wet; Layered - Multi-colored Black, Tan, and Gray; 95% Medium to High Plasticity Fines; 5% Fine Sand
Abundand organic matter.
Material is Soft to Very Soft below 2.0 ft.
Thin orange nodular mineral layers observed.

TP14 (4F-99-14)

214,870 N., 2,098,900 E.



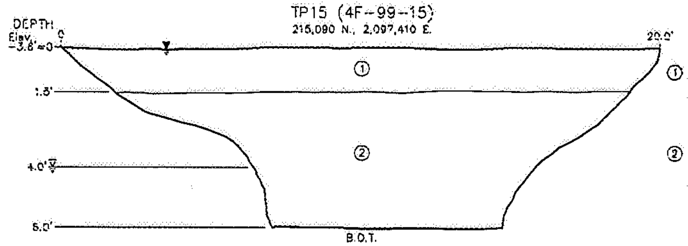
Ground water at 4.5 ft. Low flow at 4.5 ft.
Easy Excavating. Side walls stable.

Sparse weedy vegetation at surface
① From 0 to 0.1 ft. POORLY GRADED SAND, (SP): Dry, 100% Fine to Medium Sand
Topsoil
② LEAN CLAY (CL): Dry to Moist; Black; 90% Medium Plasticity Fines; 10% Fine Sand; Some Organic Matter (Roots)

Alluvium (Peat)
③ ORGANIC CLAY, (OH) AND FAT CLAY, (CH): Soft to Very Soft; Wet; Layered - Multi-colored Black, Tan, and Gray; 95% High Plasticity Fines; 5% Fine Sand.
Abundant organic matter.

TP15 (4F-99-15)

215,090 N., 2,097,410 E.

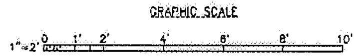


Ground water at 4.0 ft. Low flow at 4.0 ft.
Easy Excavating. Side walls stable.

Dense vegetation at surface
Topsoil
① LEAN CLAY (CL): Dry to Moist; Black; 90% Medium Plasticity Fines; 10% Fine to Medium Sand; Some Organic Matter (Roots)
Thin, poorly graded sand, (SP) layer at 0.3 ft.

Alluvium (Peat)
② ORGANIC CLAY, (OH) AND FAT CLAY, (CH): Soft to Very Soft; Wet; Layered - Multi-colored Black, Tan, and Gray; 95% High Plasticity Fines; 5% Fine Sand
Abundand organic matter.

GRAPHIC SCALE



NOTES:

1. Legend, notes, and location of explorations are shown on sheet no. B1.0.
2. Logs of explorations are shown on sheet nos. B1.1 through B1.10.

US Army Corps of Engineers
Sacramento District

DEPARTMENT OF THE ARMY CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA	Designed by: M. Ramsbotham
	Dwn by: R.L.T. / Spec No.: 1124
	Date: / Design file no: 52-25-100 / Rev.
SACRAMENTO DISTRICT GEOTECHNICAL BR., IN-HOUSE DESIGN 1325 "J" STREET SACRAMENTO, CA 95814-2922	Reviewed by: M. Ramsbotham / Drawing Code:
	Submitted by: /s/ David A. Rossette / File name / Plot date / Plot scale

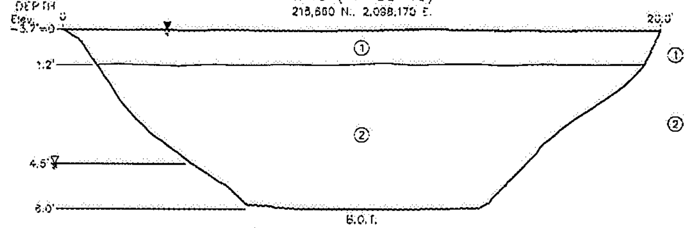
SOLANO COUNTY CALIFORNIA
PROSPECT ISLAND RESTORATION PROJECT
PH 1 & PH 2: CONSTRUCTION & REVEGETATION

LOG OF EXPLORATIONS
TP13 (4F-99-13) THROUGH TP15 (4F-99-15)

Sheet reference number:
B1.5
Sheet of

Reference - Exploration Log file no: 2nd Design Section Sheet No. 52-01-402

TP16 (4F-99-16)
218,680 N., 2,098,170 E.



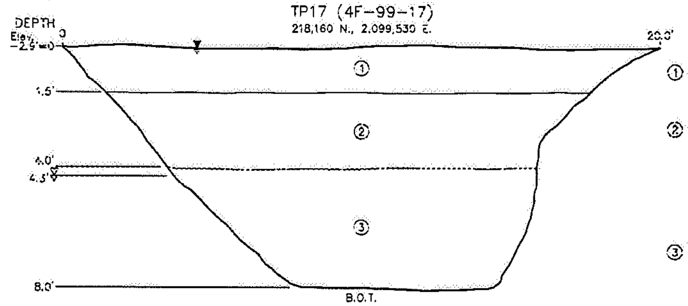
Ground water at 4.5 ft. Low flow at 4.5 ft. Easy Excavating. Side walls stable.

Sparse vegetation at surface

Topsoil
① LEAN CLAY (CL): Dry to Moist; Black; 90% Medium Plasticity Fines; 10% Fine to Medium Sand; Some Organic Matter (Roots)
Very soft at 0.5 ft.

Alluvium (Peat)
② ORGANIC CLAY, (OH) AND FAT CLAY, (CH): Soft to Very Soft; Moist to Wet; Layered – Multi-colored Black, Tan, and Gray; 95% High Plasticity Fines; 5% Fine Sand
Abundant organic matter
Thin orange nodular mineral layer at 5.5 ft. depth

TP17 (4F-99-17)
218,160 N., 2,099,530 E.



Ground water at 4.3 ft. Water perched on clay layer at 5.0 ft. Moderate flow at 4.3 ft. Easy Excavating. Side walls caved.

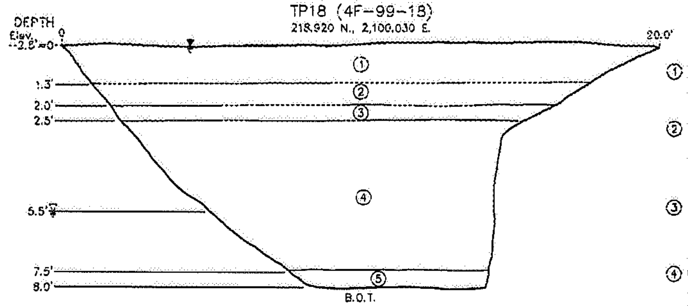
Grass and weedy vegetation at surface

Topsoil
① LEAN CLAY (CL): Dry to Moist; Black; 90% Medium Plasticity Fines; 10% Fine Sand; Some Organic Matter (Roots)

Alluvium (Peat)
② ORGANIC CLAY, (OH) AND FAT CLAY, (CH): Soft to Very Soft; Moist to Wet; Layered – Multi-colored Black, Tan, and Gray; 95% High Plasticity Fines; 5% Fine to Medium Sand
Layered organic matter throughout
Material is Soft to Very Soft below 1.0 ft.
Thin orange nodular mineral layer at 3.5 ft. depth

Alluvium (Possible Marine Sediment)
③ FAT CLAY (CH): Very Soft to Firm; Wet; Blue-Gray; 100% High Plasticity Fines

TP18 (4F-99-18)
218,920 N., 2,100,030 E.



Ground water at 5.5 ft. Water perched on clay layer at 7.5 ft. Minor flow into trench. Easy Excavating. Side walls caved.

Grass and weedy vegetation at surface

Topsoil
① LEAN CLAY (CL): Dry to Moist; Black; 90% Medium to High Plasticity Fines; 10% Fine Sand; Some Organic Matter (Roots)

Alluvium
② LEAN CLAY, (CL) AND FAT CLAY, (CH): Firm to Stiff; Moist; Layered – Multi-colored Black, Tan, and Gray; 90% Medium to High Plasticity Fines; 10% Fine Sand
Material is Soft to Very Soft below 1.5 ft.

Alluvium
③ SANDY LEAN CLAY, (CL): Firm; Moist; 60% Low to Medium Plasticity Fines; 40% Fine to Medium Sand with orange mineral nodules throughout

Alluvium
④ LEAN CLAY, (CL) AND FAT CLAY, (CH): Stiff to Very Soft; Moist to Wet; Layered – Multi-colored Black, Tan, and Gray; 95% High Plasticity Fines; 5% Fine Sand

Alluvium (Possible Marine Sediment)
⑤ FAT CLAY, (CH): Stiff to Firm; Wet; Blue-Gray; 100% High Plasticity Fines

GRAPHIC SCALE

1"=2' 0 1' 2' 4' 6' 8' 10'

NOTES

1. Legend, notes, and location of explorations are shown on sheet no. B1.0.
2. Logs of explorations are shown on sheet nos. B1.1 through B1.10.

US Army Corps of Engineers Sacramento District

DEPARTMENT OF THE ARMY CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA

SACRAMENTO DISTRICT GEOTECHNICAL BR. IN-HOUSE DESIGN 1325 J STREET SACRAMENTO, CA 95814-2922

Designed by: M. Ramsbotham | Dwn by: M.L.T. | Spec No.: 1134 | Reviewed by: M. Ramsbotham | Design file no. 32-25-492

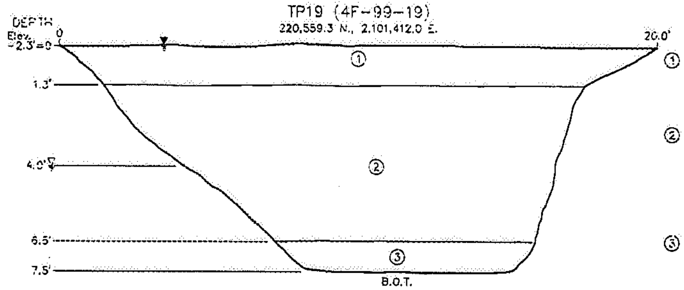
SOLANO COUNTY CALIFORNIA
PROSPECT ISLAND RESTORATION PROJECT
PH 1 & PH 2: CONSTRUCTION & REVEGETATION

LOG OF EXPLORATIONS
TP16 (4F-99-16) THROUGH TP18 (4F-99-18)

Sheet reference number: B1.6

TP19 (4F-99-19)

220,559.3 N., 2,101,412.0 E.



Grass and weedy vegetation at surface

① Topsoil
LEAN CLAY (CL): Dry to Moist; Black; 90% Medium to High Plasticity Fines; 10% Fine Sand; Some Organic Matter (Roots)

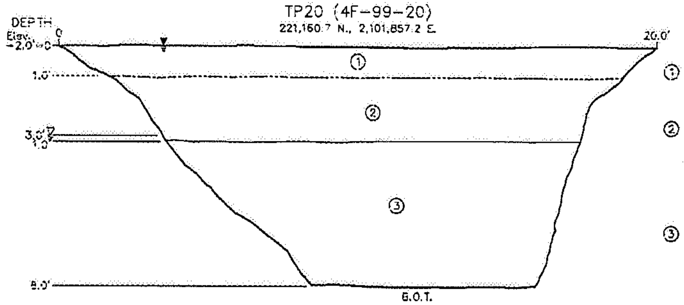
Alluvium
② LEAN CLAY (CL) AND FAT CLAY (CH): Firm to Soft; Moist; Layered – Multi-colored Black, Tan, and Gray; 90% Medium to High Plasticity Fines; 10% Fine Sand
Material is Soft to Very Soft below 1.5 ft. Thin orange nodular mineral layer at 4.0 ft. depth

Alluvium (Possible Marine Sediment)
③ FAT CLAY (CH): Stiff to Soft; Wet; Blue-Gray; 100% High Plasticity Fines

Ground water at 4.0 ft. Water perched on blue clay layer at 6.5 ft. Moderate flow at 5.0 ft.

TP20 (4F-99-20)

221,160.7 N., 2,101,857.2 E.



Thick vegetation at surface

Topsoil
① LEAN CLAY (CL): Dry to Moist; Black; 90% Medium to High Plasticity Fines; 10% Fine Sand; Some Organic Matter (Roots)

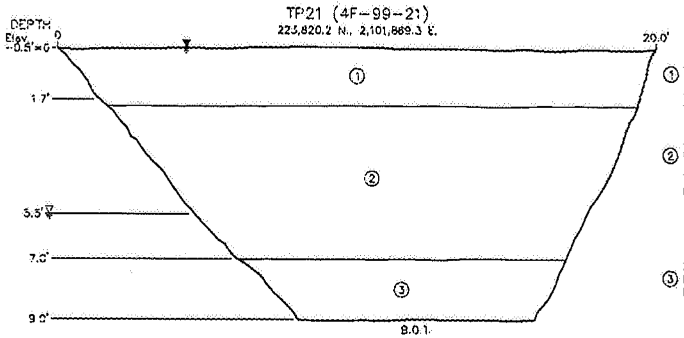
Alluvium
② FAT CLAY (CH): Stiff to Very Soft; Moist to Wet; Layered – Multi-colored Black, Tan, and Gray; 90% Medium to High Plasticity Fines; 10% Fine Sand
Material is Soft to Very Soft below 1.0 ft. Thin orange nodular mineral layer at 3.2 ft. depth

Alluvium
③ FAT CLAY (CH): Very Soft to Stiff; Wet; Blue-Gray; 100% High Plasticity Fines
Material is Stiff below 4.5 ft.

Ground water at 3.0 ft. Water perched on blue clay layer at 3.2 ft. Easy Excavating. Side walls marginally stable

TP21 (4F-99-21)

223,820.2 N., 2,101,869.3 E.



Thick vegetation at surface

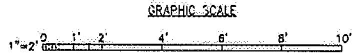
Topsoil
① LEAN CLAY (CL): Dry to Moist; Black; 80% to 90% Medium to High Plasticity Fines; 10% to 20% Fine to medium Sand; Some Organic Matter (Roots)

Alluvium
② LEAN CLAY (CL) AND FAT CLAY (CH): Firm to Very Soft; Moist to Wet; Layered – Multi-colored Black, Tan, and Gray; 90% Medium to High Plasticity Fines; 10% Fine Sand
Material is Soft to Very Soft below 1.5 ft. Thin orange nodular mineral layer at 2.5 ft. and 4.0 ft. depth

Alluvium (Possible Marine Sediment)
③ FAT CLAY (CH): Firm; Wet; Blue-Gray; 95% High Plasticity Fines; 5% Fine Sand
Material is Stiff below 8.0 ft. depth

Ground water at 5.5 ft. Water perched on blue clay layer at 7.0 ft. Easy Excavating. Side walls caved.

GRAPHIC SCALE



NOTES

1. Legend, notes, and location of explorations are shown on sheet no. B1.0.
2. Logs of explorations are shown on sheet nos. B1.1 through B1.10.

US Army Corps of Engineers
Sacramento District

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

SACRAMENTO DISTRICT
GEOTECHNICAL BR., IN-HOUSE DESIGN
1325 'J' STREET
SACRAMENTO, CA 95814-2922

Designed by: M. Ramsbotham		Date:
Dwn by: N.L.T.	Spec No.: 1124	Design file no. 32-25-491
Reviewed by: M. Ramsbotham		Drawing Code:
Submitted by: /s/ David A. Ripkoh... Chief, Soil Des. Sec.		File name: ... Plot date: Plot scale: 1:1

SOLANO COUNTY CALIFORNIA
PROSPECT ISLAND RESTORATION PROJECT
PH. 1 & PH. 2: CONSTRUCTION & REVEGETATION

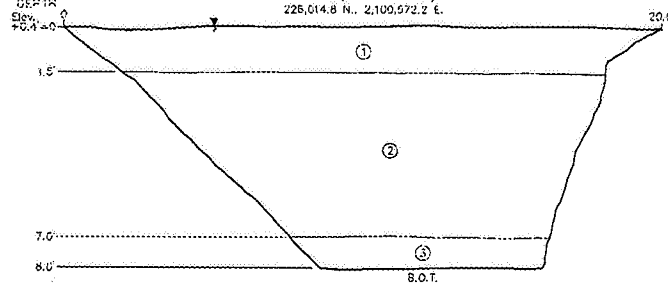
LOG OF EXPLORATIONS
TP19 (4F-99-19) THROUGH TP21 (4F-99-21)

Sheet reference number:
B1.7
Sheet of

Reference – Exploration Log. Fig. no.: 32-01-402
Soil Design Section Sheet No. 8 of 11

TP22 (4F-99-22)

226,014.8 N., 2,100,572.2 E.



Very thick and tall vegetation at surface

Topsoil

① LEAN CLAY (CL): Dry to Moist; Brown; 85% to 90% Low to Medium Plasticity Fines; 10% to 15% Fine to Medium Sand; Some Organic Matter (Roots)

Alluvium

② LEAN CLAY, (CL) AND FAT CLAY, (CH): Stiff to Very Stiff; Moist to Wet; Layered - Multi-colored Black, Tan, and Gray; 90% Medium to High Plasticity Fines; 10% Fine Sand
Material is Softer below 2.0 ft.

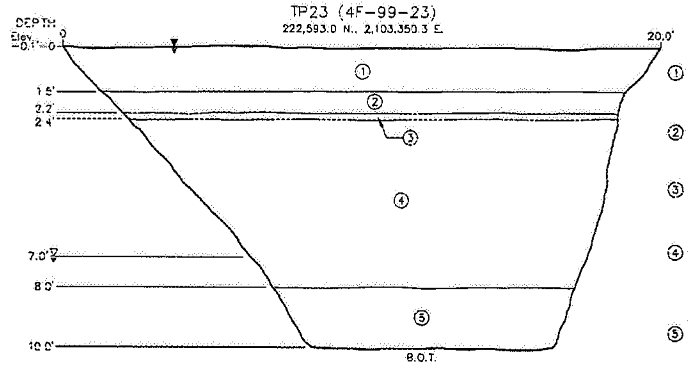
Alluvium (Possible Marine Sediment)

③ FAT CLAY, (CH): Firm; Wet; Blue-Gray; 95% Medium to High Plasticity Fines; 5% Fine Sand

Ground water was not observed. Easy Excavating. Side walls did not cave.

TP23 (4F-99-23)

222,593.0 N., 2,103,350.3 E.



Thick vegetation at surface

Topsoil

① SANDY LEAN CLAY (CL): Dry to Moist; Tan; 60% Low to Medium Plasticity Fines; 40% Fine to Medium Sand; Some Organic Matter (Roots)

Alluvium

② LEAN CLAY WITH SAND, (CL): Stiff; Moist; Tan-Brown; 80% Medium Plasticity Fines; 20% Fine to Medium Sand

Alluvium

③ SANDY SILT, (ML): Firm; Dry to Moist; Orange; 60% Low Plasticity Fines; 40% Fine to Medium Sand

Alluvium (Peat)

④ ORGANIC CLAY, (OH) AND FAT CLAY, (CH): Firm to Soft; Moist to Wet; Layered - Multi-colored Black, Tan, and Gray; 90% High Plasticity Fines; 5% Fine Sand
Abundant organic matter

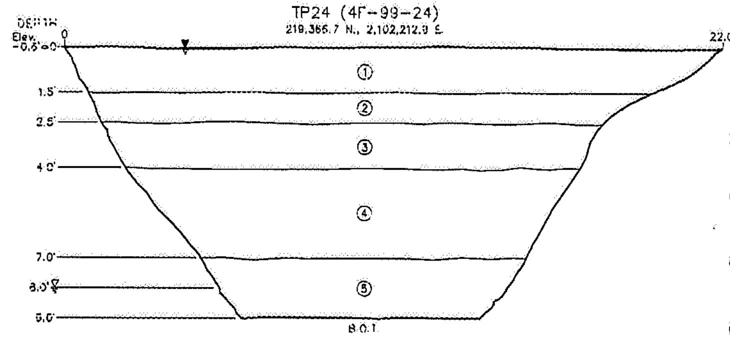
Alluvium (Possible Marine Sediment)

⑤ FAT CLAY, (CH): Firm; Wet; Blue-Gray; 100% High Plasticity Fines

Ground water at 7.0 ft. Minor flow at 7.0 ft. Easy Excavating. Side walls did not cave.

TP24 (4F-99-24)

219,366.7 N., 2,102,212.9 E.



Thick vegetation at surface

Topsoil

① LEAN CLAY WITH SAND, (CL): Dry to Moist; Tan; 75% Low to Medium Plasticity Fines; 25% Fine to Medium Sand; Some Organic Matter (Roots)

Alluvium

② BORDERLINE SILT, (ML)/LEAN CLAY, (CL): Firm; Moist; Black and Tan; 80% Low to Medium Plasticity Fines; 20% Fine to Medium Sand

Alluvium

③ FAT CLAY, (CH): Firm to Soft; Moist; Black and Tan; 90% Medium to High Plasticity Fines; 10% Fine Sand
Material is Softer below 3.0 ft.

Alluvium (Peat)

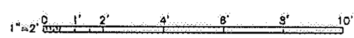
④ ORGANIC CLAY, (OH) AND FAT CLAY, (CH): Very Soft to Soft; Wet; Black; 95% High Plasticity Fines; 5% Fine Sand
Abundant organic matter

Alluvium (Possible Marine Sediment)

⑤ FAT CLAY, (CH): Stiff; Wet; Blue-Gray; 100% High Plasticity Fines

Ground water at 8.0 ft. Ground water perched on blue clay layer. Easy Excavating. Side walls did no cave.

GRAPHIC SCALE



NOTES:

1. Legend, notes, and location of explorations are shown on sheet no. B1.0.
2. Logs of explorations are shown on sheet nos. B1.1 through B1.10.

US Army Corps of Engineers
Sacramento District

Symbol | Description | Date | Approved

Designed by: M. Ramsbottom | Date: | Rev.
Dwn by: R.L.T. | Spec No.: 1126 | Design file no. 52-25-402
Reviewed by: M. Ramsbottom | Drawing Code:
Submitted by: /s/ David A. Ricketts | Plot scale: | Plot date:

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

SACRAMENTO DISTRICT
GEOTECHNICAL BR., IN-HOUSE DESIGN
1325 J STREET
SACRAMENTO, CA 95814-2922

SOLANO COUNTY CALIFORNIA
PROSPECT ISLAND RESTORATION PROJECT
PH. 1 & PH. 2: CONSTRUCTION & REVEGETATION

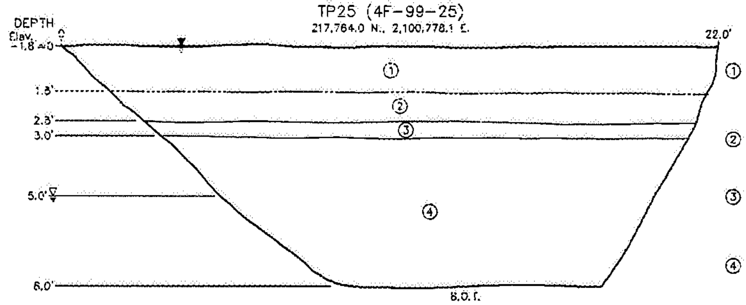
LOG OF EXPLORATIONS
TP22 (4F-99-22) THROUGH TP24 (4F-99-24)

Sheet reference number:
B1.8
Sheet of

Reference - Exploration Log Ok. No. Soil Design Section Sheet No. 52-01-402

TP25 (4F-99-25)

217,764.0 N., 2,100,778.1 E.



Thick vegetation at surface

Topsoil

① <u>LEAN CLAY WITH SAND, (CL)</u>: Dry to Moist; Tan; 80% Medium Plasticity Fines; 20% Fine to Medium Sand; Some Organic Matter (Roots)

Thin orange nodular mineral layers at 1.5ft.

Alluvium

② <u>LEAN CLAY, (CL) AND FAT CLAY, (CH)</u>: Stiff; Moist; Black and Tan; 90% Medium to High Plasticity Fines; 10% Fine Sand

Alluvium

③ <u>SANDY CLAY, (CL)</u>: Stiff; Moist; Tan; 60% Low to Medium Plasticity Fines; 40% Fine to Medium Sand

Material softer below 3 ft.

Alluvium

④ <u>FAT CLAY, (CH)</u>: Firm to Very Soft; Moist to Wet; Black and Tan; 95% Medium to High Plasticity Fines; 5% Fine Sand

Thin orange nodular mineral layers at 4.5ft.

Ground water at 5.0 ft. Minor flow at 5.0 ft.
Easy Excavating. Side walls caved.

GRAPHIC SCALE

1"=2' 0 1' 2' 4' 6' 8' 10'

NOTES:

1. Legend, notes, and location of explorations are shown on sheet no. B1.0.
2. Logs of explorations are shown on sheet nos. B1.1 through B1.10.

US Army Corps of Engineers Sacramento District

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

SACRAMENTO DISTRICT
GEOTECHNICAL BR., IN-HOUSE DESIGN
1325 J STREET
SACRAMENTO, CA 95814-2922

SOLANO COUNTY CALIFORNIA
PROSPECT ISLAND RESTORATION PROJECT
PH 1 & PH 2 CONSTRUCTION & REVEGETATION

LOG OF EXPLORATION
TP25 (4F-99-25)

Sheet reference number:
B1.9

P-1A

DEPTH		
0 – 5.0'	CL	Sandy Clay, (CL): About 65% fines with medium plasticity, medium to high toughness; about 35% fine to medium sand; micaceous; brown; moist
5.0' – 6.0'	CH	Fat Clay, (CH): About 90–95% fines with high plasticity, high toughness; about 5–10% fine sand; mottled brown and dark gray; moist to wet; water at 6.0'±
6.0' – 6.5'	PT	Peat, (PT): Greater than 95% humus material, fibrous, spongy; various stages of decomposition; dark brown; organic odor; moist to wet; less than 5% fines
6.5' – 7.5'	CH	Fat Clay, (CH): Similar to 5.0'–6.0' material except with occasional organic material; dark gray; tough; wet
7.5'	BOH	Installed 10' of 2"⌀ PVC with 2.5' stickup. Backfilled annular space with clean sand 1.0' to 7.5', and 0 to 1.0' with bentonite.

P-1B

75' West of P-1A

DEPTH		
0 – 1.5' (water 0.6')	SC	Clayey Sand, (SC): About 55–60% fine to medium sand; about 35–45% fines with medium to high plasticity; micaceous; brown and light gray mottled with occasional orgaic material; moist; water at 0.6'±
1.5' – 3.5'	CL	Sandy Clay, (CL): About 65–70% fines with medium plasticity; about 30–35% fine sand; mottled brown and light to dark gray; wet; soft
3.5' – 5.0'	CH	FAT Clay, (CH): About 95% fines with high plasticity; about 5% fine sand; mottled brown and gray; soft; wet; hole squeezing at 1.5'
5.0' – 6.0'	OH	Organic Soil, (OH): About 45% organic material, occasional fibers can be seen; about 55% fines with meldum to high plasticity, black; soft; wet
6.0'	BOH	Installed 10' of 2"⌀ PVC with 4.0' stickup. Backfilled annular space with clean sand 1.0' to 6.0', and 0 to 1.0' with bentonite.

P-2

DEPTH		
0 – 3.0'	SM	Silty Sand, (SM): About 55–65% fine to medium sand; about 35–45% fines with no to low plasticity; brown; moist
3.0' – 4.5' (water 4.0')	CL	Lean Clay, (CL): About 70–75% fines with medium to high plasticity; about 25–30% fine sand; mottled rust and gray; moist; water at 4.0'±
4.5' – 6.0'	CH	Fat Clay, (CH): About 90–95% fines with high plasticity, about 5–10% fine sand; rust and gray, mottled; firm; wet; dark gray at 5.5' to 6.0'
6.0' – 8.5'	OH	Organic Soil, (OH): About 55% fines with high plasticity; about 45% organic material; fibrous; various stages of decomposition; organic odor; black; wet
8.5' – 9.0'	PT	Peat, (PT): Greater than 95% organic material; fibrous; various stages of decomposition; organic odor; dark brown to black; less than 5% fines; wet
9.0'	BOH	Installed 10' of 2"⌀ PVC with 1.0' stickup. Backfilled annular space with clean sand 1.0' to 9.0', and 0 to 1.0' with bentonite.

P-3

DEPTH		
0 – 0.3'	CL	Poorly Graded Sand, (SP): About 95% fine to coarse sand; micaceous; about 5% nonplastic fines; salt and pepper color; wet; H_2O encountered at ground surface
0.3' – 6.5'	CH	Fat Clay, (CH): About 95% fines with high plasticity; about 5% fine sand; rust, brown, and dark gray mottled; very firm; wet; hole squeezing from 2.7' to 5.0' 2.7' to 5.0' dark gray 5.0' to 6.5' black with occasional humus material
6.5'	BOH	Installed 10' of 2"⌀ PVC with 3.5' stickup. Backfilled annular space with clean sand 1.0' to 6.5', and 0 to 1.0' with bentonite.

GRAPHIC SCALE

1"=2' 0 1' 2' 4' 6' 8' 10'

NOTES:

1. Legend, notes, and location of explorations are shown on sheet no. B1.0.
2. Logs of explorations are shown on sheet nos. B1.1 through B1.10.
3. Explorations P-1A, -1B, -2 and -3 were accomplished using a 3"± diameter hand auger with observation well installation. Locations are approximate.

US Army Corps of Engineers Sacramento District

DEPARTMENT OF THE ARMY CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA

SACRAMENTO DISTRICT GEOTECHNICAL BR. IN-HOUSE DESIGN 1325 'J' STREET SACRAMENTO, CA 95814-2922

Designed by: M. Ramsbotham | Dwn by: R.L.T. | Spec No.: 1124 | Design file no.: 52-26-400 | Reviewed by: M. Ramsbotham | Submitted by: /s/ David A. Roberts

SOLANO COUNTY CALIFORNIA
PROSPECT ISLAND RESTORATION PROJECT
PH 1 & PH 2 CONSTRUCTION & REVEGETATION

LOG OF EXPLORATIONS
P-1A, -1B, -2 AND -3
(2F-98-1A, -1B, -2 AND -3)

Sheet reference number: B1.10

Appendix D. Geotechnical Boring Data

Surface Conditions:	Levee crown (*Conversion from NGVD29 to NAVD88 is +2.57ft.)	Date Completed:	1/24/2007
Groundwater:	Groundwater not measured.	Logged By:	D. Frazer
		Total Depth:	86-1/2 feet
Method:	Hollow Stem Auger/Mud Rotary	Boring Diameter:	8 inch/4 inch
Equipment:	CME 75 with 140lb. Automatic Hammer		

Approximate Elevation: 21.0 feet (NGVD29*)
Approximate Northing: 1866429.27 feet
Approximate Easting: 6659131.97 feet

Elevation (ft., msl)	Depth (feet)	Sample Type	FIELD: Sample No.	FIELD: Blows/6 inches	FIELD: Pocket Penetrometer (tsf)	LABORATORY: Dry Density (pcf)	LABORATORY: Moisture Content (%)	LABORATORY: Liquid Limit	LABORATORY: Plasticity Index	LABORATORY: Passing #4 Sieve (%)	LABORATORY: Passing #200 Sieve (%)	LABORATORY: Other Tests	Graphic Log	DESCRIPTION
			1a 1b	7 8 11										**Sandy FAT CLAY With Gravel** (CH): Dark brown (7.5YR 3/3), moist, firm, high plasticity, about 30% fine to coarse sand, about 15% fine gravel, high dry strength, slow dilatancy, medium toughness (Levee Fill)
			2a 2b	10 7 8										**Sandy LEAN CLAY** (CL): Brown, moist, firm, medium plasticity, about 30% fine to medium sand, medium dry strength, slow dilatancy, medium toughness (Levee Fill)
16	5		3a 3b	7 11 14										**LEAN CLAY** (CL): Gray brown (2.5Y 5/2), moist, firm, medium plasticity, medium dry strength, slow dilatancy, medium toughness (Levee Fill)
			4a 4b	6 10 11										Dark brown (7.5YR 3/3)
11	10		5a 5b	5 9 10										Interbedded clayey sand layers
			6a 6b	2 4 5										**FAT CLAY** (CH): Gray brown (2.5Y 5/2), moist, firm, high plasticity, high dry strength, slow dilatancy, medium toughness (Levee Fill)
6	15		7a 7b	1 3 3										Gray (2.5Y 5/1), soft
			8a 8b	2 2 4										
1	20		9a 9b	1 4 4										**FAT CLAY With Sand**: Gray (2.5Y 5/2), moist, soft, high plasticity, about 15% fine to medium sand, high dry strength, slow dilatancy, medium toughness
			10a 10b	1 2 4										Yellow brown (7.5YR 5/6)
-4	25		11a 11b	2 2 5										Brown (7.5YR 4/4)
			12a 12b	2 4 5										Firm

P-LOG_2006 BLOWS PER 6 INCHES 73783-R9C.GPJ 6/12/07

KLEINFELDER

Drafted By: M. Hocking
Date: 6/12/2007
Project No.: 73783/2.5R9c
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Elevation (ft., msl)	Depth (feet)	Sample Type	Sample No.	Blows/6 inches	Pocket Penetrometer (tsf)	Dry Density (pcf)	Moisture Content (%)	Liquid Limit	Plasticity Index	Passing #4 Sieve (%)	Passing #200 Sieve (%)	Other Tests	Graphic Log	DESCRIPTION
-9	30		13a 13b	3 4 5										Gray (2.5Y 5/1)
			14a 14b	2 3 5										**SILT** (ML): Gray brown (10YR 5/2), moist, soft, low plasticity, medium dry strength, slow dilatancy, medium toughness
-14	35		15a 15b	2 4 5										**FAT CLAY With Sand** (CH): Gray (2.5Y 5/1), moist, firm, high plasticity, about 15% fine to medium sand, medium dry strength, slow dilatancy, medium toughness
			16a 16b	1 3 6										
-19	40		17a 17b	2 3 4							62			**Sandy LEAN CLAY** (CL): Light brown (7.5YR 6/3), moist, soft, medium plasticity, about 38% fine to medium sand, medium dry strength, slow dilatancy, medium toughness
			18a 18b	10 11 24						93	11			**Well Graded SAND With Silt** (SW-SM): Brown (2.5Y 4/4), moist, fine to coarse sand, about 7% fine gravel, about 11% fines
-24	45		19a 19b	12 19 17										
			20a 20b	32 32 24						57	7	Sieve; see Plate J-3		About 43% fine gravel, about 7% fines
-29	50		21a 21b	12 19 23										**LEAN CLAY** (CL): Light gray (2.5Y 7/1), moist, hard, medium plasticity, medium dry strength, slow dilatancy, medium toughness
			22a 22b	15 19 22										Light brown (7.5YR 6/3)
-34	55		23a 23b	13 17 21										**Clayey SAND** (SC): Brown (7.5YR 4/4), moist, about 30% fine to medium sand
			24a 24b	10 11 18										**SILT** (ML): Yellow brown (10YR 5/6), moist, firm, low plasticity, medium dry strength, slow dilatancy, medium toughness
-39	60		25a 25b	21 36 35										**LEAN CLAY** (CL): Yellow brown (10YR 5/6), moist, very hard, medium plasticity, medium dry strength, slow dilatancy, medium toughness

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Elevation (ft., msl)	Depth (feet)	Sample Type	Sample No.	Blows/6 inches	Pocket Penetrometer (tsf)	Dry Density (pcf)	Moisture Content (%)	Liquid Limit	Plasticity Index	Passing #4 Sieve (%)	Passing #200 Sieve (%)	Other Tests	Graphic Log	DESCRIPTION
-44	65		26a 26b	19 20 25										
														Sandy SILT (ML): Brown (7.5YR 4/4), moist, firm, low plasticity, about 37% fine sand, medium dry strength, slow dilatancy, medium toughness
-49	70		27a 27b	18 15 16										
-54	75		28a 28b	6 6 8							63			
														Poorly Graded SAND With Clay (SP-SC): Brown (7.5YR 4/4), wet, fine to coarse sand, about 7% fines
-59	80		29a 29b	21 24 12							7			
-64	85		30a 30b	18 18 24										**LEAN CLAY** (CL): Gray (2.5Y 5/1), moist, very hard, medium plasticity, medium dry strength, slow dilatancy, medium toughness
														Boring completed at a depth of 86-1/2 feet below existing site grade.
-69	90													
-74	95													

KLEINFELDER

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P-LOG_2006 BLOWS PER 6 INCHES 73783-R9C.GPJ 6/12/07

Surface Conditions:	Levee crown (*Conversion from NGVD29 to NAVD88 is +2.57ft.)	Date Completed:	12/11/2006
Groundwater:	Groundwater not measured.	Logged By:	C. Wilhite
		Total Depth:	56-1/2 feet
Method:	Hollow Stem Auger/Mud Rotary	Boring Diameter:	8 inch/4 inch
Equipment:	CME 750 with 140lb. Automatic Hammer		

Approximate Elevation: 17.3 feet (NGVD29*)
Approximate Northing: 1865451.90 feet
Approximate Easting: 6658923.74 feet

Elevation (ft., msl)	Depth (feet)	Sample No.	Blows/6 inches	Pocket Penetrometer (tsf)	Dry Density (pcf)	Moisture Content (%)	Liquid Limit	Plasticity Index	Passing #4 Sieve (%)	Passing #200 Sieve (%)	Other Tests	DESCRIPTION
		1a 1b	3 6 8	4.25								**LEAN CLAY With Sand** (CL): Olive brown (2.5Y 4/3), moist, firm, medium plasticity, about 15% fine to medium sand, medium dry strength, slow dilatancy, medium toughness (Levee Fill)
		2a 2b	4 7 9							62		**Sandy SILT** (ML): Olive brown (2.5Y 4/3), moist, firm, low plasticity, about 38% fine to medium sand, medium dry strength, slow dilatancy, medium toughness (Levee Fill)
12	5											
		3a 3b	5 6 6									
		4a 4b	4 6 9							35		**Silty SAND** (SM): Olive brown (2.5Y 4/4), moist, fine to medium sand, about 35% fines, (Levee Fill)
7	10											
		5a 5b	5 7 10									
		6a 6b	5 5 4							31		Fine sand, about 31% fines
2	15											
		7a 7b	2 2 3	0.25								**LEAN CLAY** (CL): Gray brown (2.5Y 5/2), moist, soft, medium plasticity, medium dry strength, slow dilatancy, medium toughness
		8a 8b	3 5 6	1.0								Interbedded silty sand layer
-3	20											
		9a 9b	0 3 5	0.5								Interbedded silty sand layer Dark gray (2.5Y 4/1)
												FAT CLAY (CH): Very dark greenish gray (GLEY 1 3/10G), moist, firm, high plasticity, high dry strength, slow dilatancy, medium toughness
		10a 10b	4 5 6	1.0								
-8	25											
		11a 11b	3 5 6	1.25								Greenish gray (GLEY 2 5/5B)
		12a 12b	5 7 11	3.0								**LEAN CLAY** (CL): Mottled greenish gray (GLEY 2 5/5B), moist, firm, medium plasticity, medium dry strength, slow dilatancy, medium toughness

KLEINFELDER

Drafted By: D. Ross
Date: 6/12/2007

Project No.: 73783/2.5R9c
File Number: 73783-R9c

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PLATE

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Elevation (ft., msl)	Depth (feet)	Sample Type	Sample No.	Blows/6 inches	Pocket Penetrometer (tsf)	Dry Density (pcf)	Moisture Content (%)	Liquid Limit	Plasticity Index	Passing #4 Sieve (%)	Passing #200 Sieve (%)	Other Tests	Graphic Log	DESCRIPTION
-13	30		13a 13b	6 13 20	4.5									Light olive brown (2.5Y 5/3), hard
			14a 14b	6 11 20	3.0									Olive brown (2.5YR 4/4)
-18	35		15a 15b	5 11 19	4.25									Firm
			16a 16b	8 11 18	>4.5									Hard
-23	40		17a 17b	6 11 17	>4.5									Firm
			18a 18b	9 11 20	>4.5									Light brown gray (2.5Y 6/2)
														Silty SAND (SM): Light olive brown (2.5Y 6/3), wet, fine to medium sand, about 24% fines
-28	45		19a 19b	4 7 6							24			
			20a 20b	3 6 7							58			**Sandy SILT** (ML): Light brown brown (2.5Y 6/2), wet, soft, low plasticity, about 42% fine to medium sand, medium dry strength, slow dilatancy, medium toughness
-33	50		21a 21b	3 3 5	1.0									
			22a 22b	9 18 26	>4.5									Olive brown (2.5Y 4/3), very hard
-38	55		23a 23b	8 13 23	4.0									Hard
														Boring completed at a depth of 56-1/2 feet below existing site grade.
-43	60													

P-LOG_2006 BLOWS PER 6 INCHES 73783-R9C.GPJ 6/12/07

KLEINFELDER

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E-104

Surface Conditions: Levee crown
(*Conversion from NGVD29 to NAVD88 is +2.57ft.)

Groundwater: Groundwater not measured.

Method: Hollow Stem Auger/Mud Rotary

Equipment: CME 75 with 140lb. Automatic Hammer

Date Completed: 1/23/2007

Logged By: D. Frazer

Total Depth: 56-1/2 feet

Boring Diameter: 8 inch/4 inch

Approximate Elevation: 17.1 feet (NGVD29*)
Approximate Northing: 1864468.95 feet
Approximate Easting: 6658741.16 feet

Elevation (ft., msl)	Depth (feet)	Sample Type	Sample No.	Blows/6 inches	Pocket Penetrometer (tsf)	Dry Density (pcf)	Moisture Content (%)	Liquid Limit	Plasticity Index	Passing #4 Sieve (%)	Passing #200 Sieve (%)	Other Tests
			1a ab	7 9 9								
			2a 2b	6 7 8								
12	5		3a 3b	4 6 8							48	
			4a 4b	3 6 6								
7	10		5a 5b	3 5 7								
			6a 6b	2 3 4								
2	15		7a 7b	2 3 4								
			8a 8b	1 3 5				66	32			Atterberg; see Plate J-2
-3	20		9a 9b	2 3 5								
			10a 10b	2 3 4								
-8	25		11a 11b	2 3 5								
			12a 12b	2 4 4								

DESCRIPTION

Sandy Lean CLAY (CL): Olive brown (7.5YR 4/4), moist, firm, medium plasticity, about 30% fine to coarse sand, with interbedded silty sand layers, medium dry strength, slow dilatancy, medium toughness (Levee Fill)

Silty SAND (SM): Olive (5Y 5/4), moist, fine to medium sand, about 48% fines, (Levee Fill)

Sandy FAT CLAY (CH): Olive (5Y 5/4), moist, firm, high plasticity, about 30% fine to medium sand, high dry strength, slow dilatancy, medium toughness (Levee Fill)

Soft, with interbedded silty sand layers

FAT CLAY With Sand (CH): Light brown (7.5YR 6/3), moist, soft, high plasticity, about 20% fine to medium sand, high dry strength, slow dilatancy, medium toughness

ELASTIC SILT (MH): Gray (2.5Y 5/1), moist, soft, high plasticity, medium dry strength, slow dilatancy, medium toughness

Light brown (7.5Y 6/4)

Gray (2.5Y 5/1)

FAT CLAY (CH): Gray (2.5Y 5/1), moist, soft, high plasticity, high dry strength, slow dilatancy, medium toughness

KLEINFELDER

Drafted By: M. Hocking
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Project No.: 73783/2.5R9c
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Elevation (ft., msl)	Depth (feet)	Sample Type	Sample No.	Blows/6 inches	Pocket Penetrometer (tsf)	Dry Density (pcf)	Moisture Content (%)	Liquid Limit	Plasticity Index	Passing #4 Sieve (%)	Passing #200 Sieve (%)	Other Tests	Graphic Log	DESCRIPTION
-13	30		13a 13b	5 7 9										Firm
			14a 14b	8 13 17										Brown (7.5YR 4/4)
-18	35		15a 15b	9 12 21										Hard
			16a 16b	11 15 21										
-23	40		17a 17b	8 12 18										**LEAN CLAY** (CL): Brown (7.5YR 4/4), moist, firm, medium plasticity, medium dry strength, slow dilatancy, medium toughness
			18a 18b	8 15 21										Light brown (7.5YR 4/4), hard
-28	45		19a 19b	12 20 31										Very hard
			20a 20b	16 19 16							16			**Silty SAND** (SM): Brown (7.5YR 4/4), moist, fine to medium sand, about 16% fines
-33	50		21a 21b	16 21 22							16			
			22a 22b	13 15 17							12			About 12% fines
-38	55		23a 23b	10 19 21							8			**Poorly Graded SAND With Silt** (SP-SM): Brown (7.5YR 4/4), wet, fine to coarse sand, about 8% fines
														Boring completed at a depth of 56-1/2 feet below existing site grade.
-43	60													

FIELD / LABORATORY

P-LOG 2006 BLOWS PER 6 INCHES 73783-R9C.GPJ 6/12/07

KLEINFELDER

Drafted By: M. Hocking
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PLATE
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E-105

Surface Conditions:	Levee crown (*Conversion from NGVD29 to NAVD88 is +2.57ft.)
Groundwater:	Groundwater not measured.
Method:	Hollow Stem Auger/Mud Rotary
Equipment:	CME 750 with 140lb. Automatic Hammer
Date Completed:	12/11/2006
Logged By:	C. Wilhite
Total Depth:	96-1/2 feet
Boring Diameter:	8 inch/4 inch

Approximate Elevation: 16.7 feet (NGVD29*)
Approximate Northing: 1863485.30 feet
Approximate Easting: 6658562.63 feet

Elevation (ft., msl)	Depth (feet)	Sample No. (FIELD)	Blows/6 inches (FIELD)	Pocket Penetrometer (tsf) (FIELD)	Dry Density (pcf) (LABORATORY)	Moisture Content (%) (LABORATORY)	Liquid Limit (LABORATORY)	Plasticity Index (LABORATORY)	Passing #4 Sieve (%) (LABORATORY)	Passing #200 Sieve (%) (LABORATORY)	Other Tests	DESCRIPTION
		1a 1b	4 5 6							45		**Silty SAND** (SM): Olive brown (5Y 4/3), moist, fine to medium sand, about 45% fines, (Levee Fill)
		2a 2b	7 8 7									Interbedded lean clay layer
12	5											
		3a 3b	5 5 5									Interbedded lean clay layer
		4a 4b	3 4 5							26		Dark olive brown (2.5Y 3/3), about 26% fines
7	10											
		5a 5b	3 4 8									
		6a 6b	4 5 6							15		About 15% fines
2	15											
		7a 7b	0 0 0	0.25								**SILT** (ML): Olive brown (2.5Y 4/3), moist, very soft, low plasticity, medium dry strength, slow dilatancy, medium toughness
		8a 8b	0 2 4	0.5 1.5								**FAT CLAY** (CH): Olive gray, moist, soft, high plasticity, high dry strength, slow dilatancy, medium toughness **LEAN CLAY** (CL): Dark brown (10YR 2/2), moist, soft, medium plasticity, medium dry strength, slow dilatancy, medium toughness
-3	20											
		9a 9b	3 4 5									**ELASTIC SILT** (MH): Dark greenish black (GLEY 2 4/10BG), moist, soft, high plasticity, medium dry strength, slow dilatancy, medium toughness
		10a 10b	2 2 4	1.25			75	41			Atterberg; see Plate J-2	
-8	25											
		11a 11b	0 5 7	0.75								Very dark gray (7.5YR 3.1), firm
		12a 12b	4 6 9	2.0								

KLEINFELDER

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Elevation (ft., msl)	Depth (feet)	Sample Type	Sample No.	Blows/6 inches	Pocket Penetrometer (tsf)	Dry Density (pcf)	Moisture Content (%)	Liquid Limit	Plasticity Index	Passing #4 Sieve (%)	Passing #200 Sieve (%)	Other Tests	Graphic Log	DESCRIPTION
		FIELD				LABORATORY								
-13	30		13a 13b	5 7 11	2.75									
			14a 14b	8 11 19	3.0									
-18	35		15a 15b	7 12 19										Olive brown (2.5Y 4/4), hard
			16a 16b	7 10 11							26			**Silty SAND** (SM): Dark gray brown (2.5Y 4/2), moist to wet, fine sand, about 26% fines
-23	40		17a 17b	8 17 24	4.25									**SILT** (ML): Light olive brown (2.5Y 5/3), moist, very hard, low plasticity, medium dry strength, slow dilatancy, medium toughness
			18a 18b	8 20 26	>4.5									**Silty SAND** (SM): Olive brown (2.5Y 4/4), moist, fine sand, about 25% fines
-28	45		19a 19b	5 5 9							40			Wet, about 40% fines
			20a 20b	7 8 13							48			About 48% fines
-33	50		21a 21b	5 7 15							9			**Poorly Graded SAND With Silt** (SP-SM): Very dark gray brown (2.5Y 3/2), wet, fine sand, about 9% fines
			22a 22b	8 13 18							7			About 7% fines
-38	55		23a 23b	5 10 14										
			24a 24b	11 14 20							4			**Poorly Graded SAND** (SP): Very dark gray brown (2.5Y 3/2), wet, fine to medium sand, about 4% fines
-43	60		25a 25b	5 11 15										Dark olive gray (5Y 3/2)

P-LOG_2006 BLOWS PER 6 INCHES 73783-R9C.GPJ 6/12/07

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Elevation (ft., msl)	Depth (feet)	Sample Type	Sample No.	Blows/6 inches	Pocket Penetrometer (tsf)	Dry Density (pcf)	Moisture Content (%)	Liquid Limit	Plasticity Index	Passing #4 Sieve (%)	Passing #200 Sieve (%)	Other Tests	Graphic Log	DESCRIPTION
-48	65		26a 26b	10 15 25							6			**Poorly Graded SAND With Silt** (SP-SM): Dark olive gray (5Y 3/2), wet, fine to medium sand, about 6% fines
-53	70		27a 27b	18 17 24										
-58	75		28a 28b	12 21 32							5			Dark blue gray (GLEY 2 4/10B), about 5% fines
-63	80		29a 29b	7 8 17										**Silty SAND** (SM): Dark blue gray (GLEY 2 4/10B), moist, fine to medium sand, about 37% fines
-68	85		30a 30b	13 23 32							37			
-73	90		31a 31b	11 20 21	>4.5									**LEAN CLAY** (CL): Light gray brown (2.5Y 5/2), moist, very hard, medium plasticity, medium dry strength, slow dilatancy, medium toughness
-78	95		32a 32b	8 11 15	3.5						68			**Sandy SILT** (ML): Olive (5Y 4/3), moist, firm, low plasticity, about 32% fine sand, medium dry strength, slow dilatancy, medium toughness
														Boring completed at a depth of 96-1/2 feet below existing site grade.

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Surface Conditions: Levee crown
(*Conversion from NGVD29 to NAVD88 is +2.57ft.)

Groundwater: Groundwater not measured.

Method: Hollow Stem Auger/Mud Rotary

Equipment: CME 75 with 140lb. Automatic Hammer

Date Completed: 1/22/2007

Logged By: D. Frazer

Total Depth: 56-1/2 feet

Boring Diameter: 8 inch/4 inch

Approximate Elevation: 16.4 feet (NGVD29*)
Approximate Northing: 1862503.26 feet
Approximate Easting: 6658373.14 feet

Elevation (ft., msl)	Depth (feet)	Sample Type	Sample No. (FIELD)	Blows/6 inches (FIELD)	Pocket Penetrometer (tsf) (FIELD)	Dry Density (pcf) (LABORATORY)	Moisture Content (%)	Liquid Limit	Plasticity Index	Passing #4 Sieve (%)	Passing #200 Sieve (%)	Other Tests	Graphic Log	DESCRIPTION
			1a 1b	9 20 26										**FAT CLAY** (CH): Light brown (7.5YR 6/3), moist, very hard, high plasticity, high dry strength, slow dilatancy, medium toughness (Levee Fill)
			2a 2b	8 16 19										**FAT CLAY With Gravel** (CH): Brown (7.5YR 5/2), moist, hard, high plasticity, about 15% fine gravel, high dry strength, slow dilatancy, medium toughness (Levee Fill)
11	5		3a 3b	4 7 11										Firm
			4a 4b	3 5 8										With interbedded silty sand layers
6	10		5a 5b	4 4 8										**Silty SAND** (SM): Brown (7.5YR 5/2), moist, fine to medium sand, about 33% fines, (Levee Fill) With interbedded lean clay layers
			6a 6b	6 4 2							33			
1	15		7a 7b	2 5 7										**FAT CLAY** (CH): Gray (2.5Y 5/1), moist, firm, high plasticity, high dry strength, slow dilatancy, medium toughness
			8a 8b	2 5 7										Gray brown (10YR 5/2)
-4	20		9a 9b	3 4 6										
			10a 10b	3 5 7										
-9	25		11a 11b	4 5 6										**FAT CLAY** (CH): Brown (7.5YR 5/4), moist, firm, high plasticity, high dry strength, slow dilatancy, medium toughness
			12a 12b	4 4 6										Gray (7.5YR 5/1)

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Elevation (ft., msl)	Depth (feet)	Sample Type	Sample No.	Blows/6 inches	Pocket Penetrometer (tsf)	Dry Density (pcf)	Moisture Content (%)	Liquid Limit	Plasticity Index	Passing #4 Sieve (%)	Passing #200 Sieve (%)	Other Tests	Graphic Log	DESCRIPTION
-14	30													
			13a 13b	2 4 5										
			14a 14b	3 4 5										
-19	35													
			15a 15b	3 5 5										Gray brown (10YR 5/2)
			16a 16b	2 3 4										**ELASTIC SILT** (MH): Very dark gray (7.5YR 3/1), moist, soft, high plasticity, medium dry strength, slow dilatancy, medium toughness
-24	40													
			17a 17b	2 4 3										
			18a 18b	5 7 7							6			**Poorly Graded SAND With Clay** (SP-SC): Gray (7.5YR 5/1), wet, fine to medium sand, about 6% fines
-29	45													
			19a 19b	2 3 4							28			**Clayey SAND** (SC): Gray (7.5YR 5/1), wet, fine to medium sand, about 28% fines
			20a 20b	4 4 8										
-34	50													
			21a 21b	2 5 8							25			About 25% fines
			22a 22b	4 4 7										
-39	55													
			23a 23b	3 4 7							27			Fine to coarse sand, about 27% fines
														Boring completed at a depth of 56-1/2 feet below existing site grade.
-44	60													

P-LOG_2006 BLOWS PER 6 INCHES 73783-R9C.GPJ 6/12/07

KLEINFELDER

Drafted By: D. Ross
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Project No.: 73783/2.5R9c
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LOG OF BORING KA-06-172
VOLUME 1 - PROBLEM IDENTIFICATION REPORT
WEST SACRAMENTO LEVEE ASSESSMENT
REACH 9C
RECLAMATION DISTRICT 900
YOLO AND SOLANO COUNTIES, CALIFORNIA

PLATE
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Surface Conditions:	Levee crown, aggregate base (*Conversion from NGVD29 to NAVD88 is +2.57ft.)	Date Completed:	12/6/2006
Groundwater:	Groundwater not measured.	Logged By:	B. Von Dessonneck/C. Wilhite
		Total Depth:	56-1/2 feet
Method:	Hollow Stem Auger/Mud Rotary	Boring Diameter:	8 inch/4 inch
Equipment:	CME 750 with 140lb. Automatic Hammer		

Approximate Elevation: 16.2 feet (NGVD29*)
Approximate Northing: 1861527.52 feet
Approximate Easting: 6658153.27 feet

Elevation (ft., msl)	Depth (feet)	Sample Type	FIELD Sample No.	Blows/6 inches	Pocket Penetrometer (tsf)	LABORATORY Dry Density (pcf)	Moisture Content (%)	Liquid Limit	Plasticity Index	Passing #4 Sieve (%)	Passing #200 Sieve (%)	Other Tests	Graphic Log	DESCRIPTION
			1a 1b	5 9 12	>4.5									**AGGREGATE BASE**: (Levee Fill) **FAT CLAY** (CH): Olive gray (5Y 4/2), moist, firm, high plasticity, about 10% fine sand, high dry strength, slow dilatancy, medium toughness (Levee Fill)
			2a 2b	8 10 11	>4.5									Very dark gray (2.5Y 3/1)
11	5		3a 3b	7 7 8	>4.5									Olive (5Y 5/4)
			4a 4b	6 8 8										**LEAN CLAY With Interbedded Silty Sand Layers** (CL): Olive (5Y 5/4), moist, firm, medium plasticity, medium dry strength, slow dilatancy, medium toughness (Levee Fill)
6	10		5a 5b	6 6 8										Interbedded silty sand layer
			6a 6b	7 7 8										Olive brown (2.5Y 4/4)
1	15		7a 7b	2 2 3	0									**Sandy LEAN CLAY** (CL): Olive brown (2.5Y 4/4), moist, soft, medium plasticity, about 30% fine sand, medium dry strength, slow dilatancy, medium toughness
			8a 8b	0 0 1	0									Very soft
-4	20		9a 9b	3 5 8	1.75									**SILT** (ML): Very dark brown (7.5YR 2.5/3), moist, firm, low plasticity, medium dry strength, slow dilatancy, medium toughness
			10a 10b	2 3 3	0.75									**LEAN CLAY** (CL): Dark gray brown (7.5YR 4/1), moist, soft, medium plasticity, medium dry strength, slow dilatancy, medium toughness
-9	25		11a 11b	0 3 4	0.5									**ELASTIC SILT** (MH): Dark gray (GLEY 2 4/10B), moist, soft, high plasticity, medium dry strength, slow dilatancy, medium toughness
			12a 12b	3 6 6	1.5									

KLEINFELDER

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LOG OF BORING KA-06-173

VOLUME 1 - PROBLEM IDENTIFICATION REPORT
WEST SACRAMENTO LEVEE ASSESSMENT
REACH 9C
RECLAMATION DISTRICT 900
YOLO AND SOLANO COUNTIES, CALIFORNIA

PLATE

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P-LOG_2006 BLOWS PER 6 INCHES 73783-R9C.GPJ 6/12/07

Elevation (ft., msl)	Depth (feet)	Sample No.	Blows/6 inches	Pocket Penetrometer (tsf)	Dry Density (pcf)	Moisture Content (%)	Liquid Limit	Plasticity Index	Passing #4 Sieve (%)	Passing #200 Sieve (%)	Other Tests	DESCRIPTION
-14	30	13a 13b	2 4 7									
		14a 14b	5 9 13									**LEAN CLAY** (CL): Blue gray (GLEY 2 6/10B), moist, firm, medium plasticity, medium dry strength, slow dilatancy, medium toughness
-19	35	15a 15b	7 12 19	3.75								Olive brown (2.5Y 4/4), hard
		16a 16b	11 26 41	>4.5								**Sandy SILT** (ML): Olive brown (2.5Y 4/4), moist, very hard, low plasticity, about 15% fine sand, medium dry strength, slow dilatancy, medium toughness
-24	40	17a 17b	6 12 16							21		**Silty SAND** (SM): Brown (2.5Y 4/4), moist, fine to medium sand, about 21% fines
		18a 18b	15 21 24									Olive brown (2.5Y 4/4)
-29	45	19a 19b	18 28 38							9		**Poorly Graded SAND With Silt** (SP-SM): Brown (7.5YR 4/4), wet, fine to medium sand, about 9% fines
		20a 20b	17 26 33									
-34	50	21a 21b	21 30 33							18		**Silty SAND** (SM): Brown (7.5YR 4/4), wet, fine to medium sand, about 18% fines
		22a 22b	21 33 37									
-39	55	23a 23b	29 35 32						99	4	Sieve; see Plate J-3	**Poorly Graded SAND** (SP): Brown (7.5YR 4/4), wet, fine to coarse sand, about 4% fines
												Boring completed at a depth of 56-1/2 feet below existing site grade.
-44	60											

KLEINFELDER

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PLATE

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P-LOG_2006 BLOWS PER 6 INCHES 73783-R9C.GPJ 6/12/07

Surface Conditions:	Levee crown, aggregate base (*Conversion from NGVD29 to NAVD88 is +2.57ft.)	Date Completed:	12/6/2006
Groundwater:	Groundwater not measured.	Logged By:	B. Von Dessonneck
		Total Depth:	56-1/2 feet
Method:	Hollow Stem Auger/Mud Rotary	Boring Diameter:	8 inch/4 inch
Equipment:	CME 750 with 140lb. Automatic Hammer		

Approximate Elevation: 15.1 feet (NGVD29*)
Approximate Northing: 1860555.86 feet
Approximate Easting: 6657917.35 feet

Elevation (ft., msl)	Depth (feet)	Sample No.	Blows/6 inches	Pocket Penetrometer (tsf)	Dry Density (pcf)	Moisture Content (%)	Liquid Limit	Plasticity Index	Passing #4 Sieve (%)	Passing #200 Sieve (%)	Other Tests	DESCRIPTION
			4									**AGGREGATE BASE**: (Levee Fill)
		1a	5									**FAT CLAY** (CH): Dark gray brown (2.5Y 4/2), moist, firm, high plasticity, high dry strength, slow dilatancy, medium toughness (Levee Fill)
		1b	9	3.4								
		2a	4 9									**Clayey SAND** (SC): Olive brown (2.5Y 4/3), moist, fine sand, about 40% fines, (Levee Fill)
		2b	10									
10	5	3a	5 7									**FAT CLAY** (CH): Olive brown (2.5Y 4/3), moist, firm, high plasticity, high dry strength, slow dilatancy, medium toughness (Levee Fill)
		3b	7									**Clayey SAND** (SC): Olive brown (2.5Y 4/3), moist, fine to medium sand, about 35% fines, (Levee Fill)
		4a	5 5	2.7								**FAT CLAY** (CH): Olive brown (2.5Y 4/3), moist, firm, high plasticity, high dry strength, slow dilatancy, medium toughness (Levee Fill)
		4b	6	1.7								
5	10	5a	5 7									**LEAN CLAY** (CL): Olive (5Y 4/4), moist, firm, medium plasticity, medium dry strength, slow dilatancy, medium toughness (Levee Fill)
		5b	9	2.0								**Sandy FAT CLAY** (CH): Olive gray (2.5Y 5/2), moist, firm, high plasticity, about 30% fine sand, high dry strength, slow dilatancy, medium toughness (Levee Fill)
		6a	6 6									**Clayey SAND** (SC): Olive gray (2.5Y 5/2), moist, fine sand, about 30% fines, (Levee Fill)
		6b	7							21		**Silty SAND** (SM): Olive gray (2.5Y 5/2), moist, fine sand, about 21% fines, (Levee Fill)
0	15	7a	3 1									**Sandy LEAN CLAY** (CL): Olive (5Y 4/3), wet, soft, medium plasticity, about 35% fine sand, medium dry strength, slow dilatancy, medium toughness
		7b	2	0.4								
		8a	2 2									**Sandy SILT** (ML): Olive (5Y 4/3), wet, very soft, low plasticity, about 25% fine sand, medium dry strength, slow dilatancy, medium toughness
		8b	2	<0.2								
-5	20	9a	3 5									**FAT CLAY** (CH): Very dark greenish gray (GLEY 1 3/5GY), wet, firm, high plasticity, high dry strength, slow dilatancy, medium toughness
		9b	6	1.4								
		10a	0 3									**LEAN CLAY** (CL): Dark greenish gray (GLEY 1 10/5Y), wet, soft, low plasticity, medium dry strength, slow dilatancy, medium toughness
		10b	4	0.3								
-10	25	11a	0 4									**ELASTIC SILT** (MH): Dark greenish gray (GLEY 1 10/5Y), moist, firm, high plasticity, medium dry strength, slow dilatancy, medium toughness
		11b	5	0.7								
		12a	4 6									
		12b	8	2.5								

KLEINFELDER

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REACH 9C
RECLAMATION DISTRICT 900
YOLO AND SOLANO COUNTIES, CALIFORNIA

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Elevation (ft., msl)	Depth (feet)	Sample Type	Sample No.	Blows/6 inches	Pocket Penetrometer (tsf)	Dry Density (pcf)	Moisture Content (%)	Liquid Limit	Plasticity Index	Passing #4 Sieve (%)	Passing #200 Sieve (%)	Other Tests	Graphic Log	DESCRIPTION
		FIELD				LABORATORY								
-15	30		13a 13b	7 9 13	2.9									
			14a 14b	9 19 30	4.5									Very hard
-20	35		15a 15b	12 22 28	>4.5									
			16a 16b	10 17 23	>4.5									
-25	40		17a 17b	13 27 43										Light olive brown (2.5Y 5/3)
			18a 18b	7 10 14							92			**SILT** (ML): Olive gray (5Y 5/2), wet, firm, low plasticity, medium dry strength, slow dilatancy, medium toughness
-30	45		19a 19b	8 12 16							50			**SANDY SILT/SILTY SAND** (ML/SM): Olive gray (5Y 5/2), moist, firm, about 50% fine sand, about 50% fines
			20a 20b	10 12 17							53			**Sandy SILT** (ML): Olive gray (5Y 5/2), wet, firm, low plasticity, about 47% fine sand, medium dry strength, slow dilatancy, medium toughness
-35	50		21a 21b	6 14 20							5			**Poorly Graded SAND With Silt** (SP-SM): Very dark gray (2.5Y 3/1), wet, fine sand, about 5% fines
			22a 22b	12 17 20										
														Poorly Graded SAND (SP): Very dark gray (2.5Y 3/1), wet, fine sand, about 4% fines
-40	55		23a 23b	8 15 21							4			
														Boring completed at a depth of 56-1/2 feet below existing site grade.
-45	60													

P-LOG_2006 BLOWS PER 6 INCHES 73783-R9C.GPJ 6/12/07

KLEINFELDER

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LOG OF BORING KA-06-174

VOLUME 1 - PROBLEM IDENTIFICATION REPORT
WEST SACRAMENTO LEVEE ASSESSMENT
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RECLAMATION DISTRICT 900
YOLO AND SOLANO COUNTIES, CALIFORNIA

PLATE

E-109

Surface Conditions:	Levee crown (*Conversion from NGVD29 to NAVD88 is +2.57ft.)	Date Completed:	12/5/2006
Groundwater:	Groundwater not measured.	Logged By:	B. Von Dessonneck
		Total Depth:	51-1/2 feet
Method:	Hollow Stem Auger/Mud Rotary	Boring Diameter:	8 inch/4 inch
Equipment:	CME 750 with 140lb. Automatic Hammer		

Approximate Elevation: 15.5 feet (NGVD29*)
Approximate Northing: 1859582.06 feet
Approximate Easting: 6657689.91 feet

Elevation (ft., msl)	Depth (feet)	Sample Type	Sample No. (FIELD)	Blows/6 inches	Pocket Penetrometer (tsf)	Dry Density (pcf) (LABORATORY)	Moisture Content (%)	Liquid Limit	Plasticity Index	Passing #4 Sieve (%)	Passing #200 Sieve (%)	Other Tests	Graphic Log	DESCRIPTION
			1a 1b	5 6 11	3.0									**FAT CLAY** (CH): Dark gray brown (2.5Y 4/2), moist, firm, high plasticity, about 5% fine sand, high dry strength, slow dilatancy, medium toughness (Levee Fill)
			2a 2b	4 9 12	3.0									
11	5		3a 3b	4 7 9	3.2									Dark gray (5Y 4/1)
			4a 4b	4 6 8	2.8									Dark gray brown (2.5Y 4/2)
6	10		5a 5b	5 5 6	2.3									Dark gray (5Y 4/1), about 5% fine sand
			6a 6b	4 4 6	3.0									**LEAN CLAY** (CL): Olive gray (5Y 4/2), moist, firm, medium plasticity, medium dry strength, slow dilatancy, medium toughness (Levee Fill)
1	15		7a 7b	4 4 4	1.7									
			8a 8b	2 1 2	0.3									**LEAN CLAY** (CL): Olive gray (5Y 4/2), moist, very soft, medium plasticity, medium dry strength, slow dilatancy, medium toughness
-5	20		9a 9b	2 4 7	1.9		60					Organic Content = 14%		**ELASTIC SILT** (MH): Very dark greenish gray (GLEY 1 3/5GY), moist, firm, high plasticity, medium dry strength, slow dilatancy, medium toughness
			10a 10b	2 3 4	1.0									
-10	25		11a 11b	0 2 3	0.5									Dark greenish gray (GLEY 1 4/5BG), wet, soft
			12a 12b	4 5 6	1.2									Firm

KLEINFELDER

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LOG OF BORING KA-06-175
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WEST SACRAMENTO LEVEE ASSESSMENT
REACH 9C
RECLAMATION DISTRICT 900
YOLO AND SOLANO COUNTIES, CALIFORNIA

PLATE
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P-LOG_2006 BLOWS PER 6 INCHES 73783-R9C.GPJ 6/12/07

Elevation (ft., msl)	Depth (feet)	Sample No.	Blows/6 inches	Pocket Penetrometer (tsf)	Passing #200 Sieve (%)	DESCRIPTION
-15	30	13a 13b	3 5 6	2.9		
		14a 14b	6 11 18	4.0		
-20	35	15a 15b	7 13 20	>4.5		Hard
		16a 16b	11 18 19	>4.5		Light olive brown (2.5Y 5/3)
-25	40					**Clayey SAND** (SC): Dark gray brown (2.5Y 4/2), wet, fine sand, about 27% fines
		17a 17b	6 9 12		27	
		18a 18b	17 30 35			
-30	45					**Silty SAND** (SM): Dark gray brown (2.5Y 4/2), wet, fine sand, about 17% fines
		19a 19b	25 32 50/4"		17	
		20a 20b	17 15 20			
-35	50	21a 21b	11 14 18		15	About 15% fines
						Boring completed at a depth of 51-1/2 feet below existing site grade.
-40	55					
-45	60					

Other column headings (no data): Sample Type; Dry Density (pcf); Moisture Content (%); Liquid Limit; Plasticity Index; Passing #4 Sieve (%); Other Tests; Graphic Log. FIELD / LABORATORY.

Surface Conditions: Levee crown
(*Conversion from NGVD29 to NAVD88 is +2.57ft.)

Groundwater: Groundwater not measured.

Method: Hollow Stem Auger/Mud Rotary

Equipment: CME 750 with 140lb. Automatic Hammer

Date Completed: 12/1/2006

Logged By: O. Khan

Total Depth: 51-1/2 feet

Boring Diameter: 8 inch/4 inch

Approximate Elevation: 15.5 feet (NGVD29*)
Approximate Northing: 1858608.87 feet
Approximate Easting: 6657460.04 feet

Elevation (ft., msl)	Depth (feet)	Sample Type	Sample No.	Blows/6 inches	Pocket Penetrometer (tsf)	Dry Density (pcf)	Moisture Content (%)	Liquid Limit	Plasticity Index	Passing #4 Sieve (%)	Passing #200 Sieve (%)	Other Tests	DESCRIPTION
			1a 1b	11 13 7									**Clayey SAND With Gravel** (SC): Dark brown (7.5YR 3/4), moist, fine to coarse sand, about 20% fine to coarse gravel, about 30% fines (Levee Fill)
			2a 2b	3 6 7	1.3 1.5								**LEAN CLAY** (CL): Dark brown (7.5YR 3/4), moist, firm, medium plasticity, medium dry strength, slow dilatancy, medium toughness (Levee Fill)
11	5		3a 3b	3 4 5	1.0								
			4a 4b	2 5 5	1.0								
6	10		5a 5b	2 4 5	0.5								**FAT CLAY** (CH): Dark brown (7.5YR 4/4), moist, soft, high plasticity, high dry strength, slow dilatancy, medium toughness (Levee Fill)
			6a 6b	2 4 4	0.5			65	40			Atterberg; see Plate J-2	
1	15		7a 7b	2 4 4	0.5								
			8a 8b	1 1 3	<0.3								**FAT CLAY** (CH): Olive brown (2.5Y 4/4), moist, soft, high plasticity, high dry strength, slow dilatancy, medium toughness
-5	20		9a 9b	0 1 3	<0.3								Light brown (7.5YR 6/4)
			10a 10b	0 4 5	<0.3 0.8								Gray (2.5Y 5/1), firm **ELASTIC SILT** (MH): Dark brown (7.5YR 3/3), moist, firm, high plasticity, medium dry strength, slow dilatancy, medium toughness
-10	25		11a 11b	0 5 7	0.5			61	24			Atterberg; see Plate J-2	Dark gray brown (2.5Y 4/2)
			12a 12b	0 3 3	0.5								Soft

KLEINFELDER

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LOG OF BORING KA-06-176
VOLUME 1 - PROBLEM IDENTIFICATION REPORT
WEST SACRAMENTO LEVEE ASSESSMENT
REACH 9C
RECLAMATION DISTRICT 900
YOLO AND SOLANO COUNTIES, CALIFORNIA

PLATE
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Elevation (ft., msl)	Depth (feet)	Sample No.	Blows/6 inches	Pocket Penetrometer (tsf)	Passing #200 Sieve (%)	DESCRIPTION
-15	30	13a 13b	0 4 4	0.5		Gray (2.5Y 5/1)
		14a 14b	3 5 5	1.0 0.8		Firm
-20	35	15a 15b	5 7 8	1.3		
		16a 16b	4 7 10	1.5 1.3		Olive gray (5Y 4/2)
-25	40	17a 17b	4 7 15	1.3		Brown (7.5YR 4/4)
		18a 18b	5 7 14	<0.5		**Clayey SAND** (SC): Brown (7.5YR 4/4), wet, fine sand, about 30% fines
-30	45	19a 19b	2 5 9		5	**Poorly Graded SAND With Silt** (SP-SM): Brown (7.5YR 4/4), wet, fine sand, about 5% fines
		20a 20b	12 14 20		18	**Silty SAND** (SM): Gray brown (2.5Y 5/2), wet, fine sand, about 18% fines
-35	50	21a 21b	7 11 17		13	About 13% fines Boring completed at a depth of 51-1/2 feet below existing site grade.
-40	55					
-45	60					

Column headings: FIELD: Sample Type, Sample No., Blows/6 inches, Pocket Penetrometer (tsf); LABORATORY: Dry Density (pcf), Moisture Content (%), Liquid Limit, Plasticity Index, Passing #4 Sieve (%), Passing #200 Sieve (%), Other Tests; Graphic Log; DESCRIPTION

KLEINFELDER

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WEST SACRAMENTO LEVEE ASSESSMENT
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PLATE
2 of 2
E-111

Surface Conditions:	Levee crown (*Conversion from NGVD29 to NAVD88 is +2.57ft.)	Date Completed:	11/30/2006
Groundwater:	Groundwater not measured.	Logged By:	C. Wilhite
		Total Depth:	51-1/2 feet
Method:	Hollow Stem Auger/Mud Rotary	Boring Diameter:	8 inch/4 inch
Equipment:	CME 750 with 140lb. Automatic Hammer		

Approximate Elevation: 15.1 feet (NGVD29*)
Approximate Northing: 1857634.19 feet
Approximate Easting: 6657234.32 feet

Elevation (ft., msl)	Depth (feet)	Sample No.	Blows/6 inches	Pocket Penetrometer (tsf)	Dry Density (pcf)	Moisture Content (%)	Liquid Limit	Plasticity Index	Passing #4 Sieve (%)	Passing #200 Sieve (%)	Other Tests
		1a 1b	7 7 10								
		2a 2b	5 7 9	2.5							
10	5										
		3a 3b	4 4 5							50	
		4a 4b	3 5 7	2.0							
5	10										
		5a 5b	2 4 8								
		6a 6b	2 4 5							26	
0	15										
		7a 7b	3 2 3								
		8a 8b	0 0 3	<0.3							
-5	20										
		9a 9b	0 2 7	<0.3							
		10a 10b	3 4 5	0.5							
-10	25										
		11a 11b	0 2 3	<0.5							
		12a 12b	0 3 3	0.8 1.5							

DESCRIPTION

LEAN CLAY With Gravel (CL): Brown (7.5YR 4/4), moist, firm, medium plasticity, about 20% fine gravel, medium dry strength, slow dilatancy, medium toughness (Levee Fill)

FAT CLAY (CH): Gray brown (2.5Y 5/2), moist, firm, high plasticity, high dry strength, slow dilatancy, medium toughness (Levee Fill)

CLAYEY SAND/LEAN CLAY (SC/CL): Light brown (7.5YR 6/4), moist, about 50% fine to medium sand, about 50% fines, (Levee Fill)

FAT CLAY (CH): Very dark brown (7.5YR 2.5/4), moist, firm, high plasticity, high dry strength, slow dilatancy, medium toughness (Levee Fill)

Silty SAND (SM): Light brown (2.5YR 4/4), moist, fine to medium sand, about 26% fines, (Levee Fill)

FAT CLAY (CH): Brown (7.5YR 5/4), moist, very soft, high plasticity, high dry strength, slow dilatancy, medium toughness

Gray brown (2.5Y 5/2), firm

ELASTIC SILT (MH): Very dark brown (7.5Y 2.5/2), wet, firm, high plasticity, medium dry strength, slow dilatancy, medium toughness

Gray brown (2.5Y 5/2), soft

Gray (2.5Y 5/1)

P-LOG_2006 BLOWS PER 6 INCHES 73783-R9C.GPJ 6/12/07

KLEINFELDER

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LOG OF BORING KA-06-177
VOLUME 1 - PROBLEM IDENTIFICATION REPORT
WEST SACRAMENTO LEVEE ASSESSMENT
REACH 9C
RECLAMATION DISTRICT 900
YOLO AND SOLANO COUNTIES, CALIFORNIA

PLATE

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Elevation (ft., msl)	Depth (feet)	Sample Type	Sample No.	Blows/6 inches	Pocket Penetrometer (tsf)	Dry Density (pcf)	Moisture Content (%)	Liquid Limit	Plasticity Index	Passing #4 Sieve (%)	Passing #200 Sieve (%)	Other Tests	Graphic Log	DESCRIPTION
-15	30		13a 13b	4 5 7	1.8									Firm
			14a 14b	5 5 10	>4.5									
-20	35		15a 15b	15 25 40	>4.5									**LEAN CLAY** (CL): Olive brown (2.5Y 4/3), moist, hard, medium plasticity, medium dry strength, slow dilatancy, medium toughness
			16a 16b	13 19 29	>4.5									Brown (7.5YR 4/4)
-25	40		17a 17b	12 15 24	>4.5									
			18a 18b	11 16 28	3.8									
-30	45		19a 19b	15 24 31	2.5 1.5						56			**Sandy SILT** (ML): Brown (7.5YR 4/4), moist, very hard, low plasticity, about 44% fine sand, medium dry strength, slow dilatancy, medium toughness
			20a 20b	28 27 28							6			**Poorly Graded SAND With Silt** (SP-SM): Brown (7.5YR 4/4), wet, fine to medium sand, about 6% fines
-35	50		21a 21b	8 15 20							10			About 10% fines
														Boring completed at a depth of 51-1/2 feet below existing site grade.
-40	55													
-45	60													

FIELD / LABORATORY

P-LOG_2006 BLOWS PER 6 INCHES 73783-R9C.GPJ 6/12/07

KLEINFELDER

Drafted By: D. Ross
Date: 6/12/2007

Project No.: 73783/2.5R9c
File Number: 73783-R9c

LOG OF BORING KA-06-177
VOLUME 1 - PROBLEM IDENTIFICATION REPORT
WEST SACRAMENTO LEVEE ASSESSMENT
REACH 9C
RECLAMATION DISTRICT 900
YOLO AND SOLANO COUNTIES, CALIFORNIA

PLATE

E-112

Surface Conditions: Levee crown
(*Conversion from NGVD29 to NAVD88 is +2.57ft.)

Groundwater: Groundwater not measured.

Method: Hollow Stem Auger/Mud Rotary

Equipment: CME 750 with 140lb. Automatic Hammer

Date Completed: 11/29/2006

Logged By: O. Khan

Total Depth: 51-1/2 feet

Boring Diameter: 8 inch/4 inch

Approximate Elevation: 14.4 feet (NGVD29*)
Approximate Northing: 1856661.96 feet
Approximate Easting: 6657000.36 feet

Elevation (ft., msl)	Depth (feet)	Sample No.	Blows/6 inches	Pocket Penetrometer (tsf)	Dry Density (pcf)	Moisture Content (%)	Liquid Limit	Plasticity Index	Passing #4 Sieve (%)	Passing #200 Sieve (%)	Other Tests	DESCRIPTION
		1a 1b	5 9 9	3.3								**LEAN CLAY** (CL): Dark brown (7.5YR 3/4), moist, firm, medium plasticity, medium dry strength, slow dilatancy, medium toughness (Levee Fill)
		2a 2b	6 6 8	2.0								
9	5	3a 3b	3 5 6	1.0								
		4a 4b	3 4 7	13 1.5								
4	10	5a 5b	3 3 5	0.5								
		6a 6b	0 2 6	0.3								**Silty SAND** (SM): Brown (2.5Y 4/2), moist, fine sand, about 16% fines, (Levee Fill)
-1	15	7a 7b	2 4 4							16		
		8a 8b	0 0 1	0.25								**LEAN CLAY** (CL): Olive brown (2.5Y 3/3), moist, soft, medium plasticity, medium dry strength, slow dilatancy, medium toughness
-6	20	9a 9b	2 3 4	1.75		47	65	25			Atterberg; see Plate J-2 Organic Content = 7%	**ELASTIC SILT** (MH): Very dark brown (7.5YR 2.5/3), moist, soft, high plasticity, medium dry strength, slow dilatancy, medium toughness
		10a 10b	0 1 3	1.0								Very dark gray (5YR 3/1)
-11	25	11a 11b	0 0 3	0.75								**LEAN CLAY** (CL): Dark blue gray (GLEY 2 4/10B), moist, very soft, medium plasticity, medium dry strength, slow dilatancy, medium toughness
		12a 12b	0 0 3	0.75								

KLEINFELDER

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File Number: 73783-R9c

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VOLUME 1 - PROBLEM IDENTIFICATION REPORT
WEST SACRAMENTO LEVEE ASSESSMENT
REACH 9C
RECLAMATION DISTRICT 900
YOLO AND SOLANO COUNTIES, CALIFORNIA

PLATE

E-113

Elevation (ft., msl)	Depth (feet)	Sample Type	Sample No.	Blows/6 inches	Pocket Penetrometer (tsf)	Dry Density (pcf)	Moisture Content (%)	Liquid Limit	Plasticity Index	Passing #4 Sieve (%)	Passing #200 Sieve (%)	Other Tests	Graphic Log	DESCRIPTION
-16	30		13a 13b	1 3 5	1.5									**FAT CLAY** (CH): Dark blue gray (GLEY 2 4/10B), moist, soft, high plasticity, high dry strength, slow dilatancy, medium toughness
			14a 14b	4 6 9	2.25									Firm
-21	35		15a 15b	4 5 10	2.25									
			16a 16b	4 7 13										
-26	40		17a 17b	8 12 17	>4.5									Greenish gray (GLEY 2 5/5GY)
			18a 18b	11 21 27	>4.5									Very hard
-31	45		19a 19b	9 18 23	2.5									**LEAN CLAY** (CL): Mottled red brown (2.5Y 5/2), moist, very hard, medium plasticity, medium dry strength, slow dilatancy, medium toughness
			20a 20b	30 35 50							19			**Silty SAND** (SM): Brown gray (2.5Y 5/2), moist, fine to medium sand, about 19% fines
-36	50		21a 21b	16 27 31							5			**Poorly Graded SAND With Silt** (SP-SM): Brown gray (2.5Y 5/2), moist, fine to medium sand, about 5% fines Boring completed at a depth of 51-1/2 feet below existing site grade.
-41	55													
-46	60													

FIELD / LABORATORY

P-LOG 2006 BLOWS PER 6 INCHES 73783-R9C.GPJ 6/12/07

KLEINFELDER

Drafted By: D. Ross
Date: 6/12/2007

Project No.: 73783/2.5R9c
File Number: 73783-R9c

LOG OF BORING KA-06-178
VOLUME 1 - PROBLEM IDENTIFICATION REPORT
WEST SACRAMENTO LEVEE ASSESSMENT
REACH 9C
RECLAMATION DISTRICT 900
YOLO AND SOLANO COUNTIES, CALIFORNIA

PLATE
2 of 2
E-113

Surface Conditions:	Levee crown (*Conversion from NGVD29 to NAVD88 is +2.57ft.)	Date Completed:	11/27/2006
Groundwater:	Groundwater not measured.	Logged By:	O. Khan
Method:	Hollow Stem Auger/Mud Rotary	Total Depth:	51-1/2 feet
Equipment:	CME 750 with 140lb. Automatic Hammer	Boring Diameter:	8 inch/4 inch

Approximate Elevation: 14.9 feet (NGVD29*)
Approximate Northing: 1855689.10 feet
Approximate Easting: 6656769.17 feet

Elevation (ft., msl)	Depth (feet)	Sample Type	Sample No.	Blows/6 inches	Pocket Penetrometer (tsf)	Dry Density (pcf)	Moisture Content (%)	Liquid Limit	Plasticity Index	Passing #4 Sieve (%)	Passing #200 Sieve (%)	Other Tests	Graphic Log	DESCRIPTION
			1a 1b	4 10 14	4.0									**LEAN CLAY** (CL): Dark brown (7.5YR 3/3), moist, firm, medium plasticity, medium dry strength, slow dilatancy, medium toughness (Levee Fill)
			2a 2b	4 5 7							64			**Sandy SILT** (ML): Yellow brown (10YR 5/6), moist, firm, low plasticity, about 36% fine sand, medium dry strength, slow dilatancy, medium toughness (Levee Fill)
10	5		3b	4 3 5	1.8									**LEAN CLAY** (CL): Dark brown (7.5YR 3/3), moist, firm, medium plasticity, medium dry strength, slow dilatancy, medium toughness (Levee Fill)
			4a 4b	2 4 6	1.5						40			**Clayey SAND** (SC): Gray brown (2.5Y 5/2), moist, fine to medium sand, about 40% fines, (Levee Fill) Interbedded lean clay layers
5	10		5b	1 3 5	2.0			92	48			Atterberg; see Plate J-2		**ELASTIC SILT** (MH): Dark brown (7.5YR 3/3), moist, soft, high plasticity, medium dry strength, slow dilatancy, medium toughness
			6b	1 4 4	0.5									
0	15		6c 6d	1 2 3										Yellow brown (10YR 5/6)
			7a 7b	0 1 3	<0.25									
-5	20		8a 8b	3 6 8	<0.25 1.0									Dark gray (7.5YR 4/1), firm
			9a 9b	3 4 5	0.8									
-10	25		10a 10b	2 2 4	<0.5			85	38			Atterberg; see Plate J-2		Soft
			11a 11b	0 4 4	<0.25									Dark gray (2.5Y 4/1)

KLEINFELDER

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LOG OF BORING KA-06-179
VOLUME 1 - PROBLEM IDENTIFICATION REPORT
WEST SACRAMENTO LEVEE ASSESSMENT
REACH 9C
RECLAMATION DISTRICT 900
YOLO AND SOLANO COUNTIES, CALIFORNIA

PLATE

E-114

Elevation (ft., msl)	Depth (feet)	Sample Type	Sample No.	Blows/6 inches	Pocket Penetrometer (tsf)	Dry Density (pcf)	Moisture Content (%)	Liquid Limit	Plasticity Index	Passing #4 Sieve (%)	Passing #200 Sieve (%)	Other Tests	Graphic Log	DESCRIPTION
-15	30													
			12a 12b	1 5 5	0.25									**LEAN CLAY** (CL): Dark gray (2.5Y 4/1), moist, firm, medium plasticity, medium dry strength, slow dilatancy, medium toughness
			13b	5 6 8	1.3									Gray (2.5Y 5/1)
-20	35													
			14a 14b	5 10 20	1.8 3.8									
			15a 15b	9 20 31	>4.5									Olive (5Y 5/6), very hard
-25	40													
			16b	9 20 28	3.5									Olive brown (2.5Y 4/4)
			17a 17b	9 14 18	2.3 2.5									Yellow brown (10YR 5/6), hard
-30	45													Brown (7.5YR 4/4), very hard
			18a 18b	10 22 42	2.0									
														Poorly Graded SAND With Silt (SP-SM): Dark gray (2.5Y 4/1), wet, fine to medium sand, about 6% fines
			19a 19b	16 24 27							6			
-35	50													
			20a 20b	10 19 22							10			About 10% fines
														Boring completed at a depth of 51-1/2 feet below existing site grade.
-40	55													
-45	60													

Surface Conditions:	Levee crown, aggregate base (*Conversion from NGVD29 to NAVD88 is +2.57ft.)	Date Completed:	11/22/2006
Groundwater:	Groundwater not measured.	Logged By:	G. Zhang
		Total Depth:	51-1/2 feet
Method:	Hollow Stem Auger/Mud Rotary	Boring Diameter:	8 inch/4 inch
Equipment:	CME 750 with 140lb. Automatic Hammer		

Approximate Elevation: 14.0 feet (NGVD29*)
Approximate Northing: 1854716.12 feet
Approximate Easting: 6656538.47 feet

Elevation (ft., msl)	Depth (feet)	Sample No. (FIELD)	Blows/6 inches (FIELD)	Pocket Penetrometer (tsf) (FIELD)	Dry Density (pcf)	Moisture Content (%)	Liquid Limit	Plasticity Index	Passing #4 Sieve (%)	Passing #200 Sieve (%)	Other Tests	DESCRIPTION
		1a 1b	11 14 12									**AGGREGATE BASE**: (Levee Fill)
		2a 2b	4 6 9									**FAT CLAY** (CH): Brown (7.5YR 4/4), moist, firm, high plasticity, high dry strength, slow dilatancy, medium toughness (Levee Fill)
9	5	3a 3b	5 5 5									**Sandy LEAN CLAY** (CL): Brown (7.5YR 4/4), moist, firm, medium plasticity, about 30% fine sand, medium dry strength, slow dilatancy, medium toughness (Levee Fill)
		4a 4b	3 5 7	0.5								**FAT CLAY** (CH): Dark gray (7.5YR 4/1), moist, firm, high plasticity, high dry strength, slow dilatancy, medium toughness (Levee Fill)
4	10	5a 5b	3 6 5							35		**Silty SAND** (SM): Dark gray (7.5YR 4/1), wet, fine to medium sand, about 35% fines
		6a 6b	3 3 3									**FAT CLAY** (CH): Dark gray (7.5YR 4/1), moist, firm, high plasticity, high dry strength, slow dilatancy, medium toughness Soft
-1	15	7a 7b	3 4 4						97	49	Sieve; see Plate J-3	**Sandy SILT** (ML): Brown (7.5YR 4/4), moist, soft, low plasticity, about 48% fine to coarse sand, medium dry strength, slow dilatancy, medium toughness
		8a 8b	0 0 1	<0.25						94		**LEAN CLAY** (CL): Olive brown (2.5Y 4/4), wet, very soft, medium plasticity, medium dry strength, slow dilatancy, medium toughness
-6	20	9a 9b	0 1 5	<0.25								**SILT** (ML): Gray (2.5Y 5/1), moist, firm, low plasticity, medium dry strength, slow dilatancy, medium toughness
		10a 10b	0 4 5	0.5			81	41			Atterberg; see Plate J-2	**ELASTIC SILT** (MH): Dark gray (2.5Y 4/1), moist, firm, high plasticity, medium dry strength, slow dilatancy, medium toughness
-11	25	11a 11b	0 2 4	<0.5								Dark gray (2.5Y 5/1), soft
		12a 12b	0 0 3	<0.25								Very soft

KLEINFELDER

Drafted By: D. Ross
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Project No.: 73783/2.5R9c
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LOG OF BORING KA-06-180
VOLUME 1 - PROBLEM IDENTIFICATION REPORT
WEST SACRAMENTO LEVEE ASSESSMENT
REACH 9C
RECLAMATION DISTRICT 900
YOLO AND SOLANO COUNTIES, CALIFORNIA

PLATE

E-115

Elevation (ft., msl)	Depth (feet)	Sample Type	Sample No.	Blows/6 inches	Pocket Penetrometer (tsf)	Dry Density (pcf)	Moisture Content (%)	Liquid Limit	Plasticity Index	Passing #4 Sieve (%)	Passing #200 Sieve (%)	Other Tests	Graphic Log	DESCRIPTION
-16	30													
			13a 13b	0 0 4	<0.5									
			14a 14b	0 5 5	0.5 0.8									
-21	35													
			15a 15b	2 5 7	0.8 1.8									
			16a 16b	6 10 19	3.5 1.3									**Clayey SAND** (SC): Dark gray (2.5Y 5/1), moist, fine sand, about 35% fines
-26	40													
			17a 17b	2 3 4							14			**Silty SAND** (SM): Dark gray (2.5Y 5/1), wet, fine sand, about 14% fines
			18a 18b	4 6 10							12			About 12% fines
-31	45													
			19a 19b	6 8 13							11			**Poorly Graded SAND With Silt** (SP-SM): Dark gray (2.5Y 5/1), wet, fine sand, about 11% fines
			20a 20b	8 12 19										**Poorly Graded SAND** (SP): Dark gray (2.5Y 5/1), fine sand, about 4% fines
-36	50													
			21a 21b	12 19 24						100	4	Sieve; see Plate J-3		
														Boring completed at a depth of 51-1/2 feet below existing site grade.
-41	55													
-46	60													

FIELD / LABORATORY

P-LOG_2006 BLOWS PER 6 INCHES 73783-R9C.GPJ 6/12/07

KLEINFELDER

Drafted By: D. Ross
Date: 6/12/2007

Project No.: 73783/2.5R9c
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LOG OF BORING KA-06-180
VOLUME 1 - PROBLEM IDENTIFICATION REPORT
WEST SACRAMENTO LEVEE ASSESSMENT
REACH 9C
RECLAMATION DISTRICT 900
YOLO AND SOLANO COUNTIES, CALIFORNIA

PLATE

E-115

Surface Conditions:	Levee crown (*Conversion from NGVD29 to NAVD88 is +2.57ft.)	Date Completed:	11/21/2006
Groundwater:	Groundwater not measured.	Logged By:	C. Wilhite
		Total Depth:	76-1/2 feet
Method:	Hollow Stem Auger/Mud Rotary	Boring Diameter:	8 inch/4 inch
Equipment:	CME 750 with 140lb. Automatic Hammer		

Approximate Elevation: 13.8 feet (NGVD29*)
Approximate Northing: 1853742.56 feet
Approximate Easting: 6656309.88 feet

Elevation (ft., msl)	Depth (feet)	Sample Type	Sample No. (FIELD)	Blows/6 inches	Pocket Penetrometer (tsf)	Dry Density (pcf)	Moisture Content (%)	Liquid Limit	Plasticity Index	Passing #4 Sieve (%)	Passing #200 Sieve (%)	Other Tests
			1a / 1b	6 / 12 / 11	>4.5							
			2a / 2b	4 / 6 / 8	>4.5							
9	5		3a / 3b	6 / 6 / 6								
			4a / 4b	2 / 4 / 6	3.5							
4	10		5a / 5b	1 / 5 / 4	1.0							
			6a / 6b	2 / 2 / 3	1.0							
-1	15		7a / 7b	1 / 4 / 6							10	
			8a / 8b	0 / 0 / 0	0.5							
-6	20		9a / 9b	0 / 1 / 5								
			10a / 10b	2 / 4 / 4	1.0							
-11	25		11a / 11b	1 / 3 / 4	1.5							
			12a / 12b	0 / 1 / 4	0.5							

DESCRIPTION

LEAN CLAY (CL): Dark yellow brown (10YR 4/4), moist, firm, medium plasticity, medium dry strength, slow dilatancy, medium toughness (Levee Fill)

Very dark brown (10YR 2/2) and mottled olive brown (2.5Y 4/3), about 10% fine sand

FAT CLAY (CH): Gray brown (2.5Y 5/2), moist, firm, high plasticity, high dry strength, slow dilatancy, medium toughness (Levee Fill)

LEAN CLAY (CL): Greenish black (GLEY 1 2.5/10Y), moist, soft, medium plasticity, about 15% fine sand, medium dry strength, slow dilatancy, medium toughness (Levee Fill)

Sandy LEAN CLAY (CL): Greenish black (GLEY 1 2.5/10Y), moist, soft, medium plasticity, medium dry strength, slow dilatancy, medium toughness
Black (7.5YR 2.5/1)

Poorly Graded SAND With Silt (SP-SM): Gray gray (GLEY 1 5/10Y), wet, fine to medium sand, about 10% fines

ELASTIC SILT (MH): Dark greenish gray (GLEY 1 4/10Y), moist, very soft, medium plasticity, medium dry strength, slow dilatancy, medium toughness

LEAN CLAY (CL): Dark greenish gray (GLEY 1 4/10Y), moist, soft, medium plasticity, medium dry strength, slow dilatancy, medium toughness
Black (2.5Y 2.5/1)

Wet

Moist

ELASTIC SILT (MH): Black (2.5Y 2.5/1), moist, soft, high plasticity, medium dry strength, slow dilatancy, medium toughness

Elevation (ft., msl)	Depth (feet)	Sample Type	Sample No.	Blows/6 inches	Pocket Penetrometer (tsf)	Dry Density (pcf)	Moisture Content (%)	Liquid Limit	Plasticity Index	Passing #4 Sieve (%)	Passing #200 Sieve (%)	Other Tests	Graphic Log	DESCRIPTION
		FIELD				LABORATORY								
-16	30													
			13a 13b	0 1 3	0.75									Very soft
			14a 14b	0 3 3	1.0									
-21	35													
			15a 15b	1 3 6	0.75									**LEAN CLAY** (CL): Black (2.5Y 2.5/1), moist, soft, medium plasticity, medium dry strength, slow dilatancy, medium toughness Dark greenish gray (GLEY 1 4/5G), firm
			16a 16b	6 8 10	2.0									
-26	40													
			17a 17b	5 7 9	2.25									**LEAN CLAY With Sand** (CL): Greenish gray (GLEY 1 5/10GY), moist, firm, medium plasticity, about 15% fine sand, medium dry strength, slow dilatancy, medium toughness **Clayey SAND** (SC): Gray (GLEY 1 5/10GY), moist, fine sand, about 30% fines
			18a 18b	3 9 13							40			**Silty SAND** (SM): Dark greenish gray (GLEY 1 4/10GY), moist, fine to medium sand, about 20% fines
-31	45													
			19a 19b	9 18 27							42			About 42% fines
			20a 20b	13 18 21										**Poorly Graded SAND With Silt** (SP-SM): Dark greenish gray (GLEY 1 4/10GY), moist, fine to medium sand, about 7% fines
-36	50													
			21a 21b	10 18 22							7			
			22a 22b	15 24 31						92	4	Sieve; see Plate J-3		**Well Graded SAND** (SW): Dark greenish gray (GLEY 1 4/10GY), wet, fine to coarse sand, about 8% fine gravel, about 4% fines
-41	55													
			23a 23b	11 18 22							6			**Poorly Graded SAND With Silt** (SP-SM): Dark greenish gray (GLEY 1 4/10GY), moist, fine to medium sand, about 6% fines
			24a 24b	20 25 30							4			**Well Graded SAND** (SW): Dark greenish gray (GLEY 1 4/10GY), moist, fine to coarse sand, about 4% fines
-46	60													
			25a 25b	11 12 18							4			

P-LOG_2006 BLOWS PER 6 INCHES 73783-R9C.GPJ 6/12/07

KLEINFELDER

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File Number: 73783-R9c

LOG OF BORING KA-06-181
VOLUME 1 - PROBLEM IDENTIFICATION REPORT
WEST SACRAMENTO LEVEE ASSESSMENT
REACH 9C
RECLAMATION DISTRICT 900
YOLO AND SOLANO COUNTIES, CALIFORNIA

PLATE
2 of 3
E-116

Elevation (ft., msl)	Depth (feet)	Sample Type	Sample No.	Blows/6 inches	Pocket Penetrometer (tsf)	Dry Density (pcf)	Moisture Content (%)	Liquid Limit	Plasticity Index	Passing #4 Sieve (%)	Passing #200 Sieve (%)	Other Tests	Graphic Log	DESCRIPTION
-51	65		26a 26b	18 22 29							4			
-56	70		27a 27b	6 9 16	2.25									**Silty SAND** (SM): Dark greenish gray (GLEY 1 4/10GY), moist, fine to medium sand, about 20% fines **Sandy SILT** (ML): Dark greenish gray (GLEY 1 4/10GY), moist, hard, low plasticity, about 30% fine sand, medium dry strength, slow dilatancy, medium toughness
-61	75		28a 28b	2 6 9	1.25									**LEAN CLAY** (CL): Dark greenish gray GLEY 1 4/5G), moist, firm, medium plasticity, trace organics, medium dry strength, slow dilatancy, medium toughness Boring completed at a depth of 76-1/2 feet below existing site grade.
-66	80													
-71	85													
-76	90													
-81	95													

FIELD: Sample Type through Pocket Penetrometer. LABORATORY: Dry Density through Other Tests.

P-LOG_2006 BLOWS PER 6 INCHES 73783-R9C.GPJ 6/12/07

KLEINFELDER

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VOLUME 1 - PROBLEM IDENTIFICATION REPORT
WEST SACRAMENTO LEVEE ASSESSMENT
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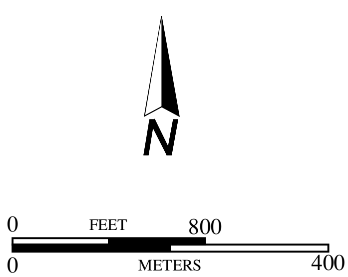
RECLAMATION DISTRICT 900
YOLO AND SOLANO COUNTIES, CALIFORNIA

PLATE

E-116



EXPLANATION

1-P-06 APPROXIMATE LOCATION OF PIEZOMETER

1-S-09 APPROXIMATE LOCATION OF STILLING WELL

BASE MAP SOURCE: GOOGLE EARTH

ENGEO — Expect Excellence

SITE PLAN
GROUND AND SURFACE WATER LEVEL MONITORING
RYER ISLAND, CALIFORNIA

PROJECT NO.: 9306.000.000	
SCALE: AS SHOWN	
DRAWN BY: SRP	CHECKED BY: JJT

PLATE NO. 2

G:\Drafting\DRAFTING2_Dwg\9306\000\071212\9306000000-2-SitePlan-0712.dwg 7-12-12 09:58:48 AM spatters

ORIGINAL FIGURE PRINTED IN COLOR

LOG OF BORING 1-P-1

ENGEO INCORPORATED

Piezometer Installation
Ryer Island Monitoring
Ryer Island, CA
9306.000.000

DATE DRILLED:	8/4/2011	LOGGED / REVIEWED BY:	AJC / ZAC
HOLE DEPTH:	Approx. 28 ft.	DRILLING CONTRACTOR:	V&W Drilling
HOLE DIAMETER:	6.0 in.	DRILLING METHOD:	Hollow Stem Auger
SURF ELEV (NGVD29):	-3.28 ft.	HAMMER TYPE:	140 lb. Auto Trip

Depth in Feet	Elevation in Feet	Sample Type	DESCRIPTION	Log Symbol	Water Level	Blow Count/Foot	PID (ppm)	Unconfined Strength (tsf) *field approx	Well Construction
5	-5		LEAN CLAY (CL), brown, medium stiff, moist, less than 30% silt, less that 5% fine-grained sand, few fine gravel			6			Flush Mount Well Box Neat Cement 2" Diameter Sch 40 PVC
	-10		LEAN CLAY (CL), bluish gray, medium stiff, moist, less than 15% silt, less than 15% fine-grained sand			8			Bentonite Filter Pack Seal
10			SANDY LEAN CLAY (CL), bluish gray to grayish blue, very stiff, moist, less than 30% fine-grained sand, less than 15% silt, less than 10% fine gravel		▽	27			#3 Sand Filter Pack
15	-15		SANDY SILT WITH GRAVEL (ML), bluish gray to grayish blue, very stiff, saturated, less than 25% fine-grained sand, less than 15% fine gravel			17 38			2" Diameter Sch 40 PVC Well Screen, 0.010 Screen
	-20		SILTY SAND (SM), bluish gray to grayish blue, loose, saturated, fine-grained sand, less than 35% silt			18			
20 25	-25 -30		POORLY GRADED SAND WITH SILT (SP-SM), brown, medium dense, saturated, fine-grained sand, less than 12% silt			20 20 18 19			Threaded bottom cap
			Bottom of boring at 28 feet. Groundwater encountered during drilling at 11 1/2 feet.						

LOG OF BORING 1-P-2

ENGEO INCORPORATED

Piezometer Installation
Ryer Island Monitoring
Ryer Island, CA
9306.000.000

DATE DRILLED: 8/5/2011
HOLE DEPTH: Approx. 26 ft.
HOLE DIAMETER: 6.0 in.
SURF ELEV (NGVD29): -2.45 ft.

LOGGED / REVIEWED BY: AJC / ZAC
DRILLING CONTRACTOR: V&W Drilling
DRILLING METHOD: Hollow Stem Auger
HAMMER TYPE: 140 lb. Auto Trip

Depth in Feet	Elevation in Feet	Sample Type	DESCRIPTION	Log Symbol	Water Level	Blow Count/Foot	PID (ppm)	Unconfined Strength (tsf) *field approx	Well Construction
	-5		LEAN CLAY WITH SAND (CL), dark greenish brown, medium stiff to stiff, moist, less than 20% fine-grained sand, less than 5% gravel		▽	22 8			Flush Mount Well Box Neat Cement 2" Diameter Sch 40 PVC
5	-10		LEAN CLAY (CL), dark greenish brown, soft, moist, less than 5% fine-grained sand			4 2			Bentonite Filter Pack Seal
10	-15		SANDY LEAN CLAY (CL), dark bluish gray, very stiff, saturated, less than 30% fine-grained sand			17 16			#3 Sand Filter Pack
15			SANDY SILT (ML), bluish gray, very stiff, saturated, less than 40% fine-grained sand			17			2" Diameter Sch 40 PVC Well Screen, 0.010 Screen
20	-20 -25		SILTY SAND (SM), light gray, very loose, saturated, fine-grained sand, less than 40% silt			6 17 10			
25			SANDY SILT (ML), grayish brown, stiff, saturated, less than 40% fine-grained sand						Threaded bottom cap
			Bottom of boring at 26 feet. Groundwater encountered at 3 feet during drilling.						

ENGEO INCORPORATED

LOG OF BORING 1-P-3

Piezometer Installation
Ryer Island Monitoring
Ryer Island, CA
9306.000.000

DATE DRILLED:	8/4/2011	LOGGED / REVIEWED BY:	AJC / ZAC
HOLE DEPTH:	Approx. 26 ft.	DRILLING CONTRACTOR:	V&W Drilling
HOLE DIAMETER:	6.0 in.	DRILLING METHOD:	Hollow Stem Auger
SURF ELEV (NGVD29):	-4.32 ft.	HAMMER TYPE:	140 lb. Auto Trip

Depth in Feet	Elevation in Feet	DESCRIPTION	Water Level	Blow Count/Foot	PID (ppm)	Unconfined Strength (tsf) *field approx	Well Construction
	-5	LEAN CLAY (CL), black, medium stiff, moist, less than 20% silt, few organics		16, 7			Flush Mount Well Box; Neat Cement; 2" Diameter Sch 40 PVC
5	-10	LEAN CLAY WITH SAND (CL), bluish gray, very stiff, moist, less than 25% fine-grained sand, less than 15% silt		22, 21			Bentonite Filter Pack Seal
10	-15	SILT WITH GRAVEL (ML), greenish brown, very stiff, saturated, less than 30% fine gravel, less than 25% clay	▽	37			#3 Sand Filter Pack
		SILTY WITH SAND (ML), brown, medium stiff, saturated, less than 30% fine-grained sand		20			
15	-20	SANDY SILT (SM), brown, medium dense, saturated, less than 40% silt, some fine gravel		22, 26			2" Diameter Sch 40 PVC Well Screen, 0.010 Screen
20	-25	(dense to very dense)		50/6", 40			
25	-30						Threaded bottom cap

Bottom of boring at 26 feet. Groundwater encountered during drilling at 9 1/2 feet.

ENGEO INCORPORATED

LOG OF BORING 1-P-4

Piezometer Installation
Ryer Island Monitoring
Ryer Island, CA
9306.000.000

DATE DRILLED: 8/4/2011
HOLE DEPTH: Approx. 26 ft.
HOLE DIAMETER: 6.0 in.
SURF ELEV (NGVD29): -2.33 ft.

LOGGED / REVIEWED BY: AJC / ZAC
DRILLING CONTRACTOR: V&W Drilling
DRILLING METHOD: Hollow Stem Auger
HAMMER TYPE: 140 lb. Auto Trip

Columns: Depth in Feet | Elevation in Feet | Sample Type | DESCRIPTION | Log Symbol | Water Level | Blow Count/Foot | PID (ppm) | Unconfined Strength (tsf) *field approx | Well Construction

Depth in Feet	DESCRIPTION	Blow Count/Foot
0	SILT (ML), brown, very stiff to stiff, moist, less than 30% clay	38, 9, 4
6	LEAN CLAY (CL), bluish gray, soft, moist, less than 25% silt	2
10	(less than 10% silt, less than 20% fine-grained sand, stiff)	15, 26
14	SILTY SAND (SM), bluish gray, dense to medium dense, moist to saturated, fine-grained sand, less than 35% silt	43, 10, 46, 42
26	Bottom of boring at 26 feet. Groundwater encountered at 15 feet during drilling.	

Depth scale: 5, 10, 15, 20, 25
Elevation scale: -5, -10, -15, -20, -25

Well Construction:
- Flush Mount Well Box
- Neat Cement
- 2" Diameter Sch 40 PVC
- Bentonite Filter Pack Seal
- #3 Sand Filter Pack
- 2" Diameter Sch 40 PVC Well Screen, 0.010 Screen
- Threaded bottom cap

ENGEO INCORPORATED

LOG OF BORING 1-P-5

Piezometer Installation
Ryer Island Monitoring
Ryer Island, CA
9306.000.000

DATE DRILLED: 8/4/2011
HOLE DEPTH: Approx. 26 ft.
HOLE DIAMETER: 6.0 in.
SURF ELEV (NGVD29): -5.45 ft.

LOGGED / REVIEWED BY: AJC / ZAC
DRILLING CONTRACTOR: V&W Drilling
DRILLING METHOD: Hollow Stem Auger
HAMMER TYPE: 140 lb. Auto Trip

Depth in Feet	Elevation in Feet	Sample Type	DESCRIPTION	Log Symbol	Water Level	Blow Count/Foot	PID (ppm)	Unconfined Strength (tsf) *field approx	Well Construction
			LEAN CLAY (CL), dark brown to black, stiff to medium stiff, moist to saturated, less than 20% silt, less than 10% fine-grained sand		∇	27 5			Flush Mount Well Box Neat Cement 2" Diameter Sch 40 PVC
5	-10		LEAN CLAY (CL), bluish gray, medium stiff, saturated, less than 10% silt			18 6			Bentonite Filter Pack Seal #3 Sand Filter Pack
10	-15		LEAN CLAY WITH SAND (CL), bluish gray, very stiff to stiff, saturated, less than 20% fine-grained sand, less than 20% silt			38 11			
15	-20		SILTY SAND WITH GRAVEL (SM), light brown, dense, saturated, fine-grained sand, less than 25% fine gravel, less than 35% silt			43 22			2" Diameter Sch 40 PVC Well Screen, 0.010 Screen
20 25	-25 -30		SILTY SAND (SM), brownish gray mottled with reddish orange, very dense to hard, saturated, less than 30% silt			74 27			Threaded bottom cap
			Bottom of boring at 26 feet. Groundwater encountered during drilling at 4 1/2 feet.						

LOG OF BORING 1-P-6

ENGEO INCORPORATED

Piezometer Installation
Ryer Island Monitoring
Ryer Island, CA
9306.000.000

DATE DRILLED: 8/5/2011
HOLE DEPTH: Approx. 26 ft.
HOLE DIAMETER: 6.0 in.
SURF ELEV (NGVD29): -4.52 ft.

LOGGED / REVIEWED BY: AJC / ZAC
DRILLING CONTRACTOR: V&W Drilling
DRILLING METHOD: Hollow Stem Auger
HAMMER TYPE: 140 lb. Auto Trip

Depth in Feet	Elevation in Feet	Sample Type	DESCRIPTION	Log Symbol	Water Level	Blow Count/Foot	PID (ppm)	Unconfined Strength (tsf) *field approx	Well Construction
5	-5 -10		LEAN CLAY WITH SAND (CL), dark grayish brown, stiff to very stiff, moist, less than 20% fine-grained sand		▽	38 8 12			Flush Mount Well Box Neat Cement 2" Diameter Sch 40 PVC
10	-15		LEAN CLAY (CL), gray, very stiff, saturated, less than 5% fine-grained snad			17 24 17			Bentonite Filter Pack Seal #3 Sand Filter Pack
15	-20		SANDY SILT (ML), light yellowish brown, stiff to very stiff, saturated, 30-40% fine-grained sand			36 19			2" Diameter Sch 40 PVC Well Screen, 0.010 Screen
20 25	-25 -30		SILTY SAND (SM), dark yellowish brown, medium dense, saturated, fine to mediuum-grained sand, less than 40% silt			27 15			Threaded bottom cap
			Bottom of boring at 26 feet. Groundwater encountered at 4 1/2 feet during drilling.						

Appendix E. Processed CPT, K_{sbt}, and PPDT Results

Presented below is a list of formulas used for the estimation of various soil properties. The formulas are presented in SI unit system and assume that all components are expressed in the same units.

:: Unit Weight, g (kN/m³) ::

$$g = g_w \cdot \left(0.27 \cdot \log(R_f) + 0.36 \cdot \log(\frac{q_t}{p_a}) + 1.236\right)$$

where g_w = water unit weight

:: Permeability, k (m/s) ::

$I_c < 3.27$ and $I_c > 1.00$ then $k = 10^{0.952-3.04 \cdot I_c}$

$I_c \leq 4.00$ and $I_c > 3.27$ then $k = 10^{-4.52-1.37 \cdot I_c}$

:: N_{SPT} (blows per 30 cm) ::

$$N_{60} = \left(\frac{q_c}{P_a}\right) \cdot \frac{1}{10^{1.1268-0.2817 \cdot I_c}}$$

$$N_{1(60)} = Q_{tn} \cdot \frac{1}{10^{1.1268-0.2817 \cdot I_c}}$$

:: Young's Modulus, Es (MPa) ::

$$(q_t - \sigma_v) \cdot 0.015 \cdot 10^{0.55 \cdot I_c + 1.68}$$

(applicable only to $I_c < I_{c\_cutoff}$)

:: Relative Density, Dr (%) ::

$$100 \cdot \sqrt{\frac{Q_{tn}}{k_{DR}}}$$

(applicable only to SBT_n: 5, 6, 7 and 8 or $I_c < I_{c\_cutoff}$)

:: State Parameter, ψ ::

$$\psi = 0.56 - 0.33 \cdot \log(Q_{tn,cs})$$

:: Peak drained friction angle, φ (°) ::

$$\varphi = 17.60 + 11 \cdot \log(Q_{tn})$$

(applicable only to SBT_n: 5, 6, 7 and 8)

:: 1-D constrained modulus, M (MPa) ::

If $I_c > 2.20$

$\alpha = 14$ for $Q_{tn} > 14$

$\alpha = Q_{tn}$ for $Q_{tn} \leq 14$

$M_{CPT} = \alpha \cdot (q_t - \sigma_v)$

If $I_c \leq 2.20$

$M_{CPT} = (q_t - \sigma_v) \cdot 0.0188 \cdot 10^{0.55 \cdot I_c + 1.68}$

:: Small strain shear Modulus, Go (MPa) ::

$$G_0 = (q_t - \sigma_v) \cdot 0.0188 \cdot 10^{0.55 \cdot I_c + 1.68}$$

:: Shear Wave Velocity, Vs (m/s) ::

$$V_s = \left(\frac{G_0}{\rho}\right)^{0.50}$$

:: Undrained peak shear strength, Su (kPa) ::

$N_{kt} = 10.50 + 7 \cdot \log(F_r)$ or user defined

$$S_u = \frac{(q_t - \sigma_v)}{N_{kt}}$$

(applicable only to SBT_n: 1, 2, 3, 4 and 9 or $I_c > I_{c\_cutoff}$)

:: Remolded undrained shear strength, Su(rem) (kPa) ::

$S_{u(rem)} = f_s$ (applicable only to SBT_n: 1, 2, 3, 4 and 9 or $I_c > I_{c\_cutoff}$)

:: Overconsolidation Ratio, OCR ::

$$k_{OCR} = \left[\frac{Q_{tn}^{0.20}}{0.25 \cdot (10.50 \cdot +7 \cdot \log(F_r))}\right]^{1.25} \text{ or user defined}$$

$OCR = k_{OCR} \cdot Q_{tn}$

(applicable only to SBT_n: 1, 2, 3, 4 and 9 or $I_c > I_{c\_cutoff}$)

:: In situ Stress Ratio, Ko ::

$$K_O = (1 - \sin\varphi') \cdot OCR^{\sin\varphi'}$$

(applicable only to SBT_n: 1, 2, 3, 4 and 9 or $I_c > I_{c\_cutoff}$)

:: Soil Sensitivity, S_t ::

$$S_t = \frac{N_S}{F_r}$$

(applicable only to SBT_n: 1, 2, 3, 4 and 9 or $I_c > I_{c\_cutoff}$)

:: Effective Stress Friction Angle, φ' (°) ::

$$\varphi' = 29.5° \cdot B_q^{0.121} \cdot (0.256 + 0.336 \cdot B_q + \log Q_t)$$

(applicable for $0.10<B_q<1.00$)

References

• Robertson, P.K., Cabal K.L., Guide to Cone Penetration Testing for Geotechnical Engineering, Gregg Drilling & Testing, Inc., 5th Edition, November 2012

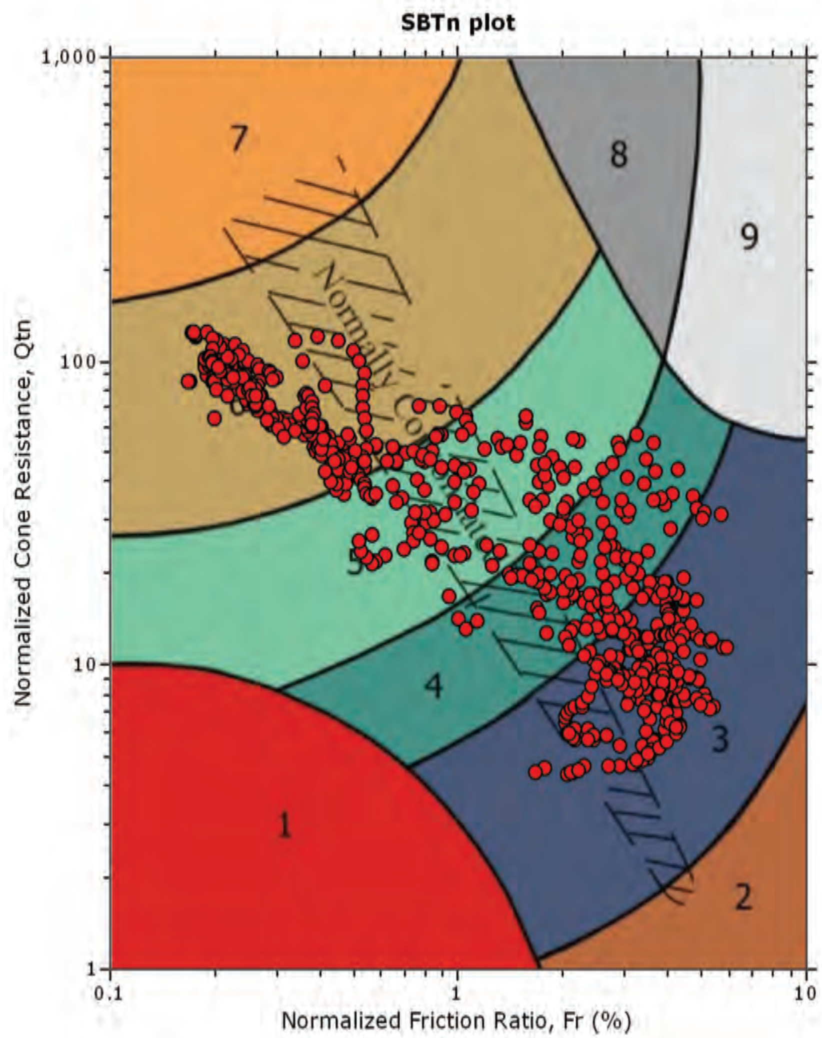
• Robertson, P.K., Interpretation of Cone Penetration Tests - a unified approach., Can. Geotech. J. 46(11): 1337–1355 (2009)

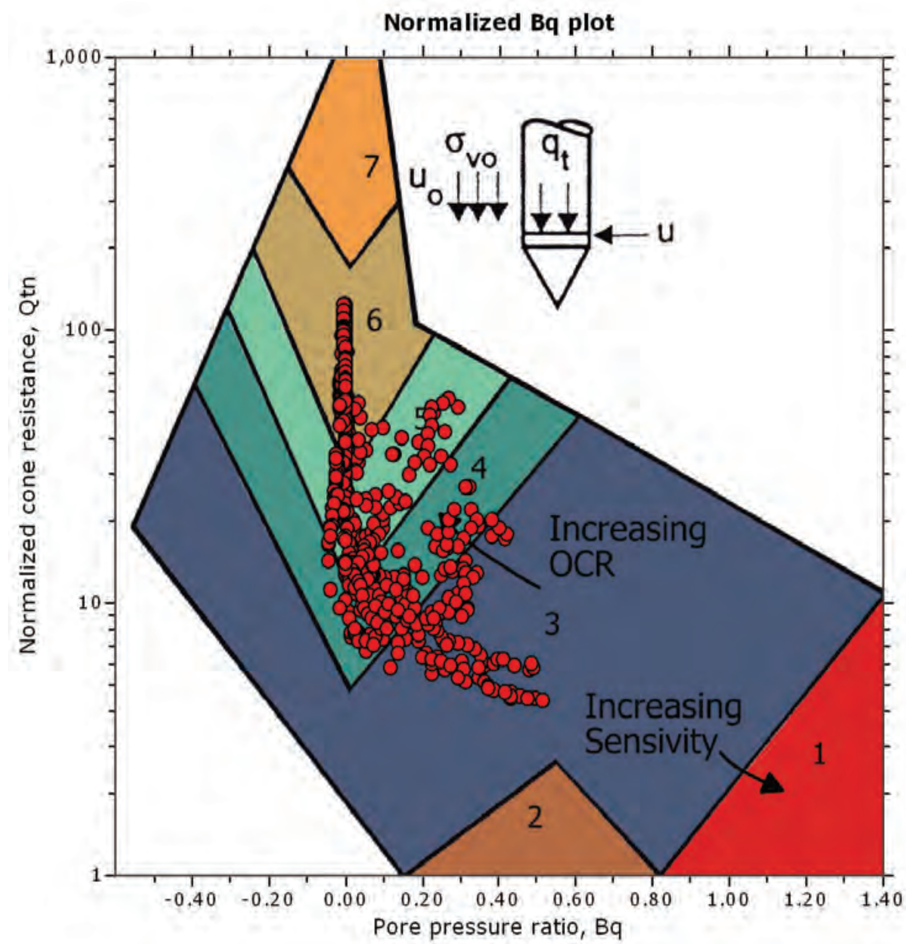
California Department of Water Resources
Division of Integrated Regional Water Management
North Central Region Office
Geology and Groundwater Investigations Section

CPT: 040RI-2
Total depth: 110.56 ft, Date: 3/13/2012
Surface Elevation: 25.68 ft
Coords: X:0.00, Y:0.00
Cone Type: CPTu
Cone Operator: Gregg Drilling & Testing, Inc.

Project: Prospect Island Tidal Habitat Restoration Project
Location: Solano County

SBT - Bq plots (normalized)





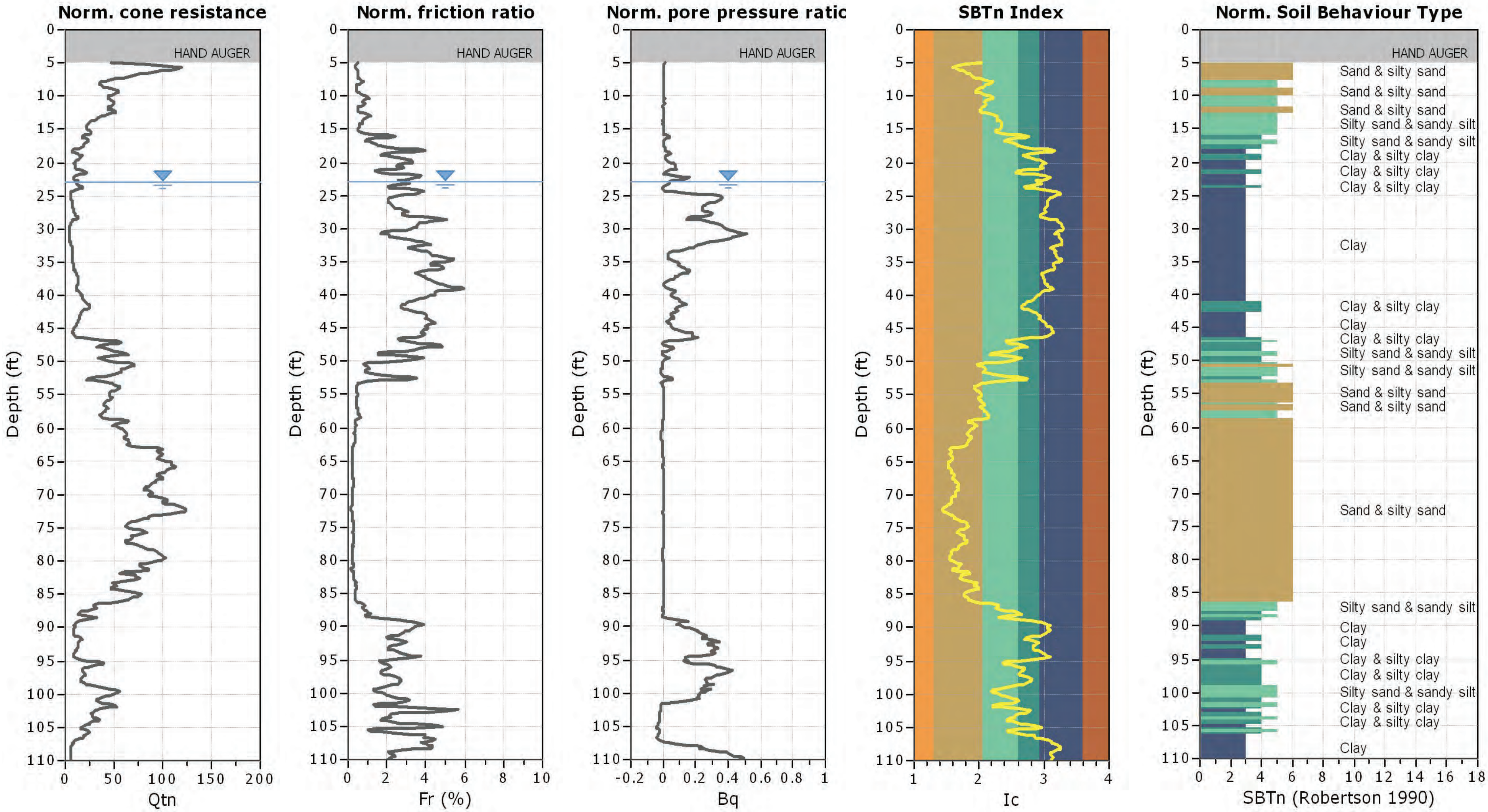
SBTn legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty clay
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to clayey sand
9. Very stiff fine grained

California Department of Water Resources
Division of Integrated Regional Water Management
North Central Region Office
Geology and Groundwater Investigations Section

CPT: 040RI-2
Total depth: 110.56 ft, Date: 3/13/2012
Surface Elevation: 25.68 ft
Coords: X:0.00, Y:0.00
Cone Type: CPTu
Cone Operator: Gregg Drilling & Testing, Inc.

Project: Prospect Island Tidal Habitat Restoration Project
Location: Solano County



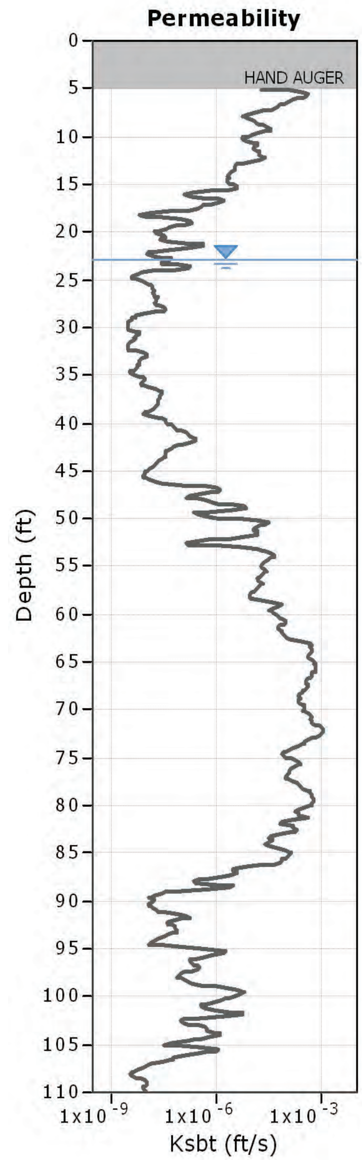
SBTn legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty clay
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to clayey sand
9. Very stiff fine grained

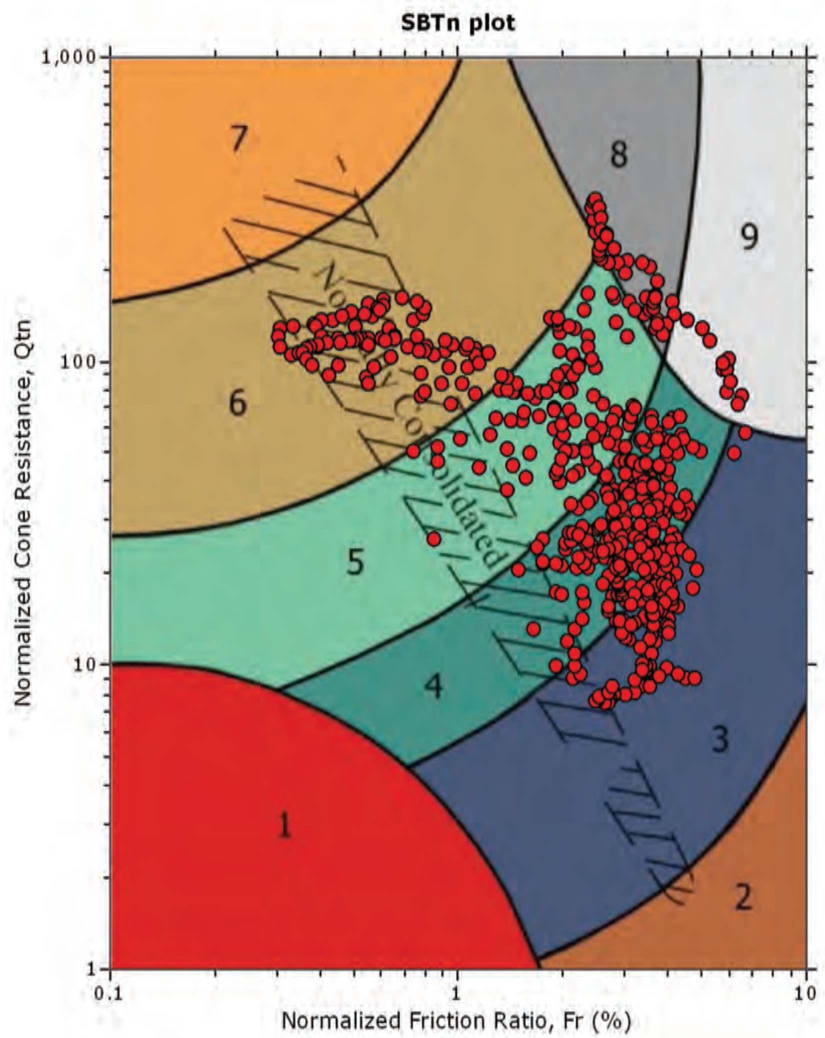
California Department of Water Resources
Division of Integrated Regional Water Management
North Central Region Office
Geology and Groundwater Investigations Section

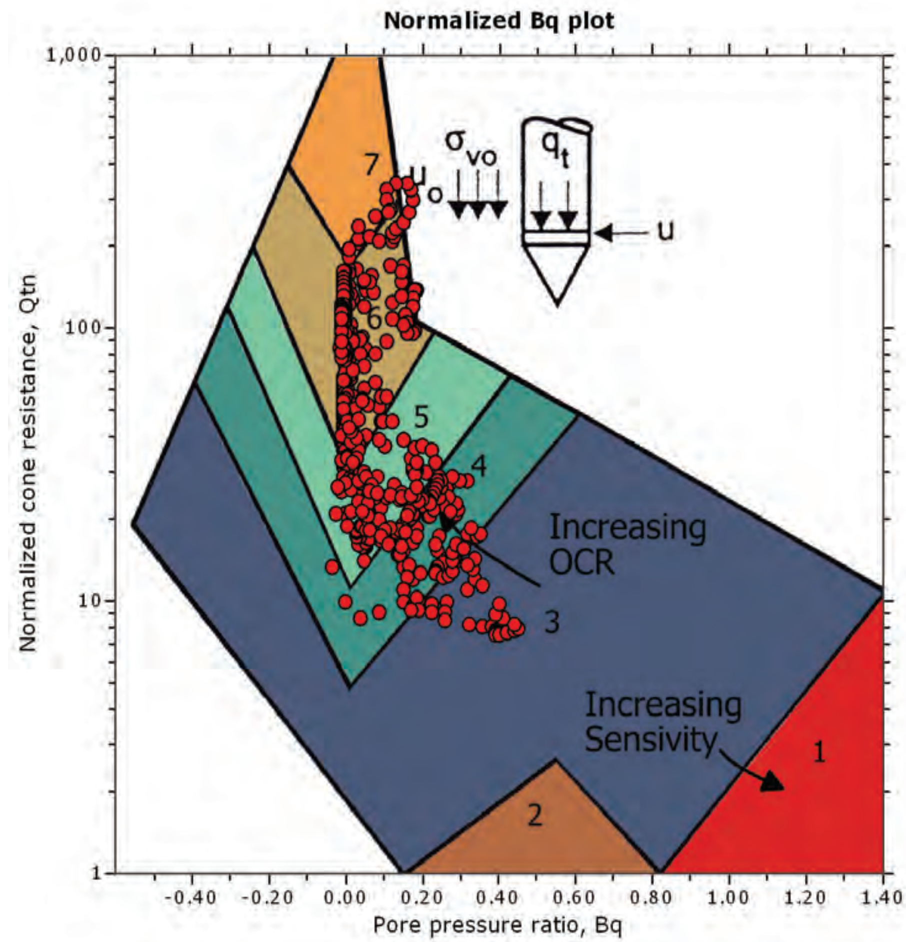
CPT: 040RI-2
Total depth: 110.56 ft, Date: 3/13/2012
Surface Elevation: 25.68 ft
Coords: X:0.00, Y:0.00
Cone Type: CPTu
Cone Operator: Gregg Drilling & Testing, Inc.

Project: **Prospect Island Tidal Habitat Restoration Project**
Location: **Solano County**



SBT - Bq plots (normalized)





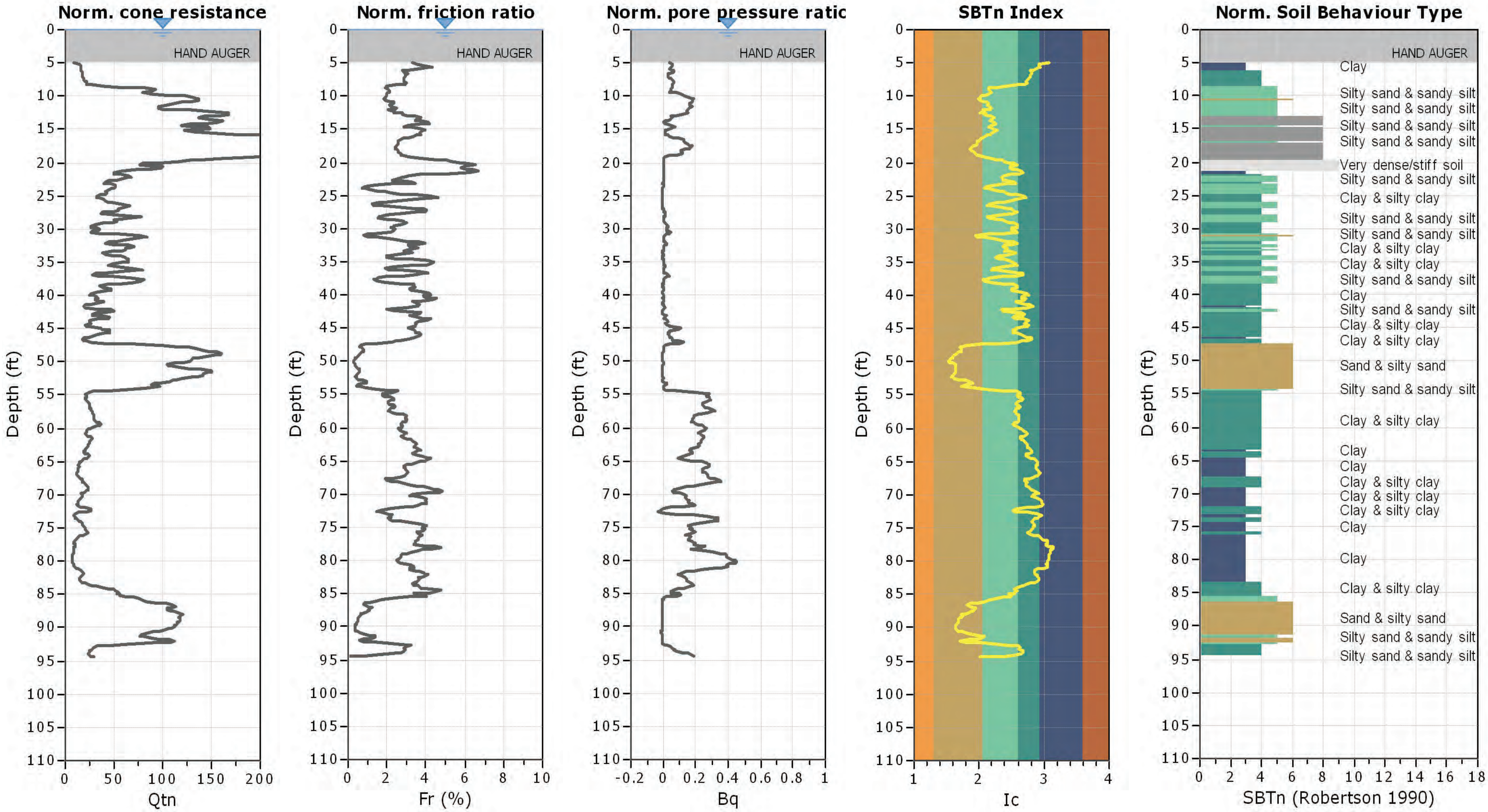
SBTn legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty clay
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to clayey sand
9. Very stiff fine grained

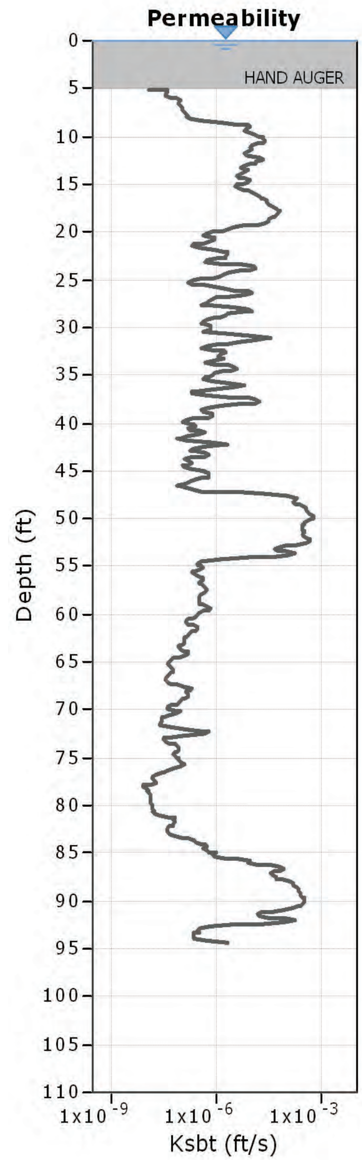
California Department of Water Resources
Division of Integrated Regional Water Management
North Central Region Office
Geology and Groundwater Investigations Section

CPT: 040RI-3
Total depth: 94.49 ft, Date: 3/13/2012
Surface Elevation: -3.15 ft
Coords: X:0.00, Y:0.00
Cone Type: CPTu
Cone Operator: Gregg Drilling & Testing, Inc.

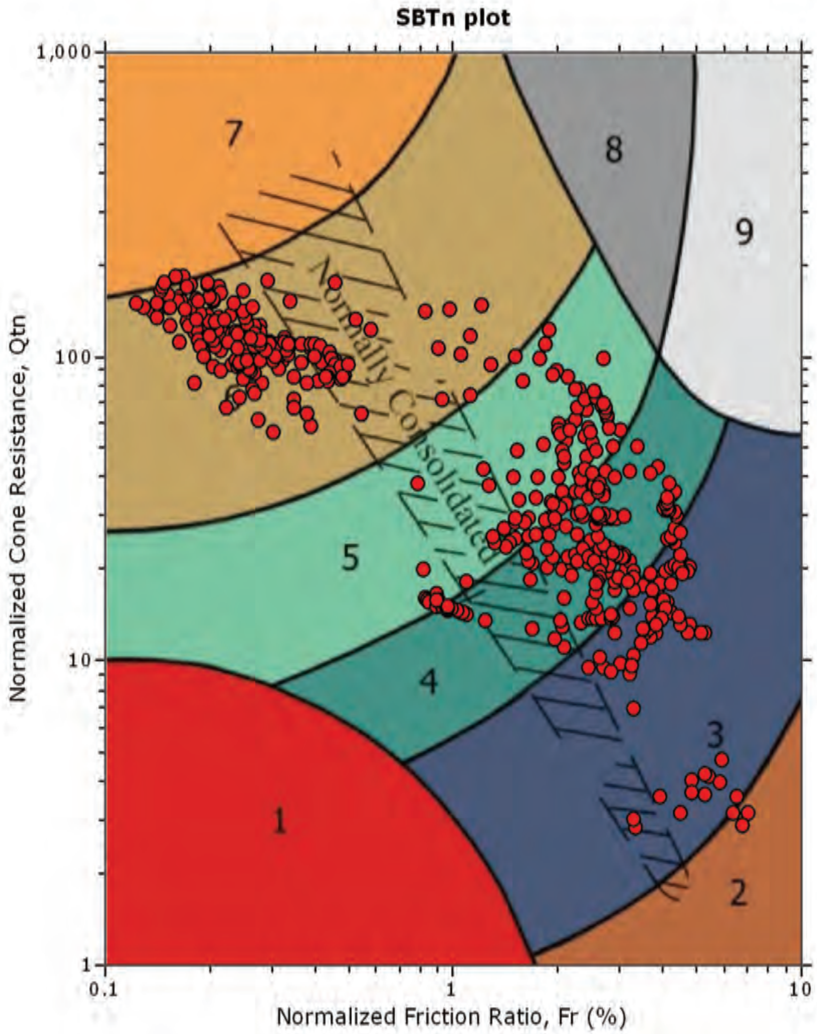
Project: **Prospect Island Tidal Habitat Restoration Project**
Location: **Solano County**

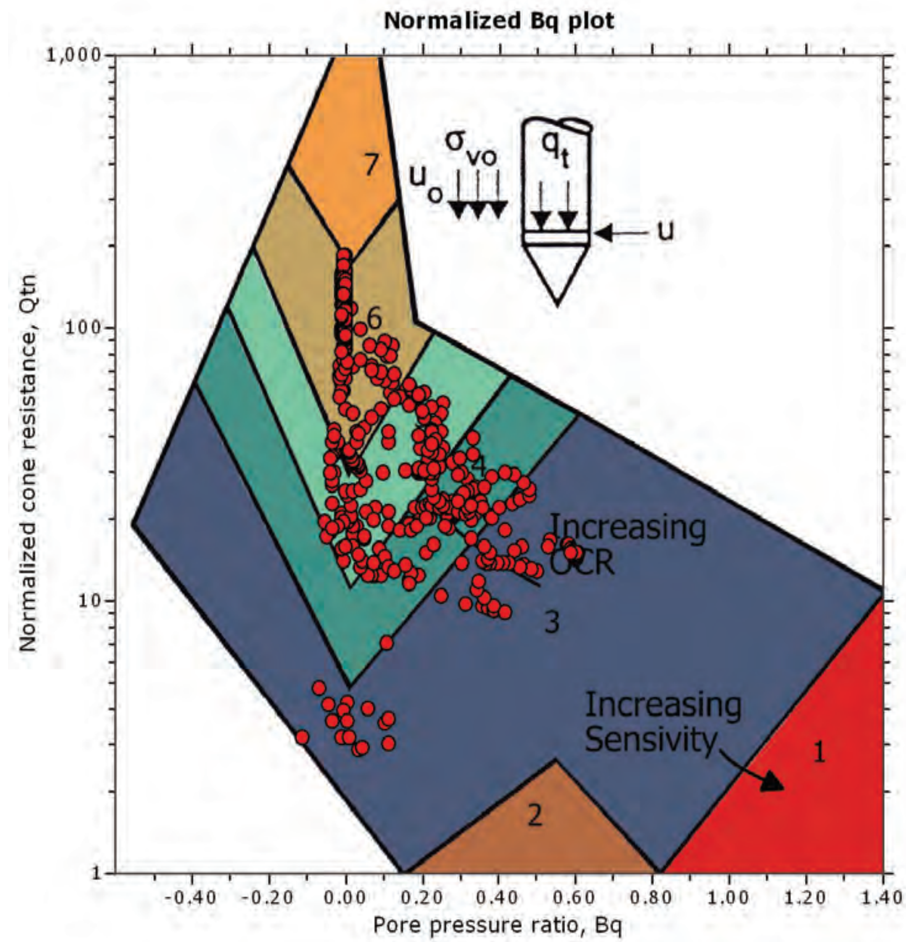


SBTn legend
1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty clay
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to clayey sand
9. Very stiff fine grained


Permeability
HAND AUGER
Depth (ft)
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
100
105
110
1x10 -9
1x10 -6
1x10 -3
Ksbt (ft/s)

SBT - Bq plots (normalized)





SBTn legend

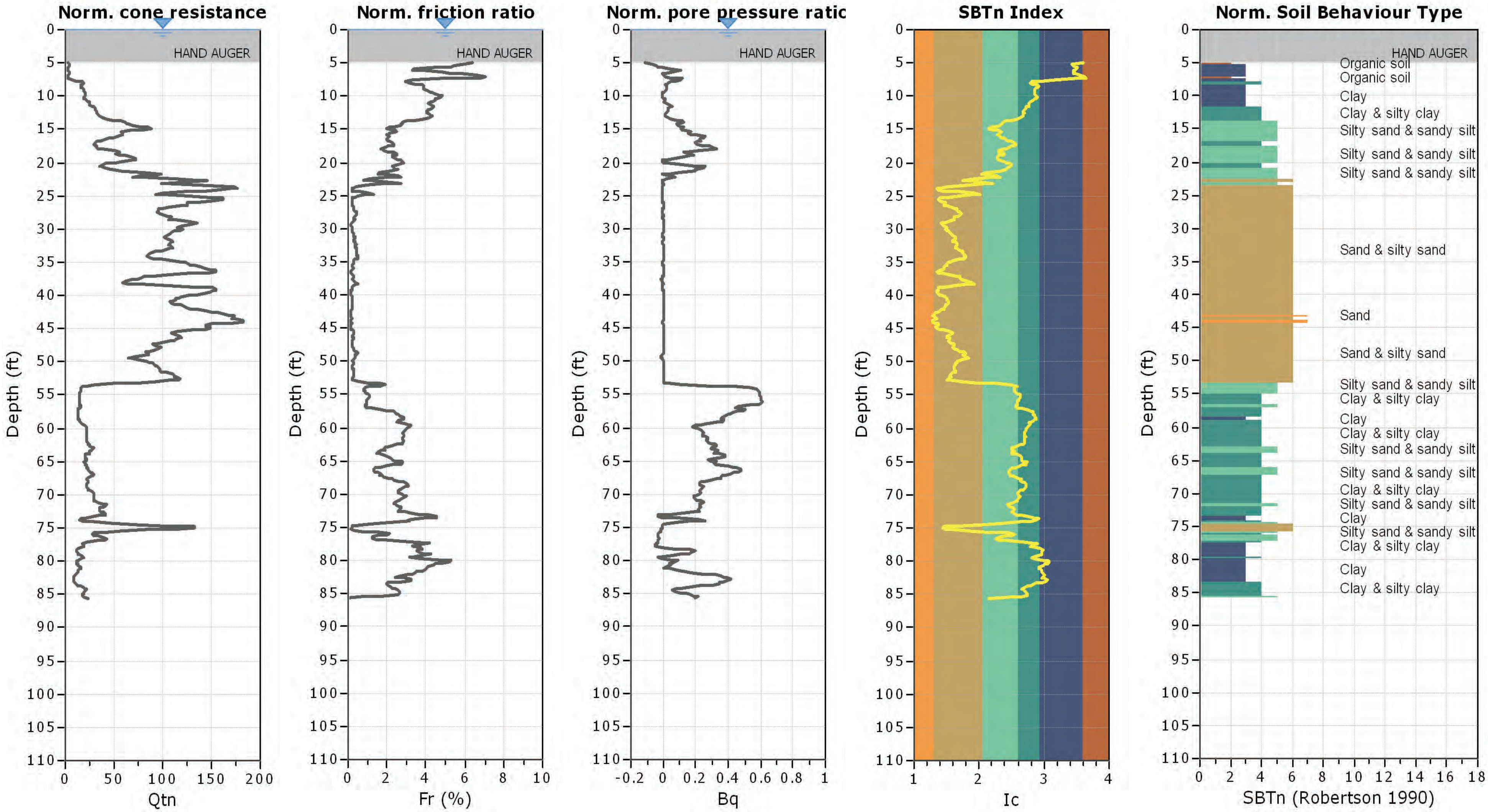
1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty clay
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to clayey sand
9. Very stiff fine grained

GEOLOGISMIKI Geotechnical Software

California Department of Water Resources
Division of Integrated Regional Water Management
North Central Region Office
Geology and Groundwater Investigations Section

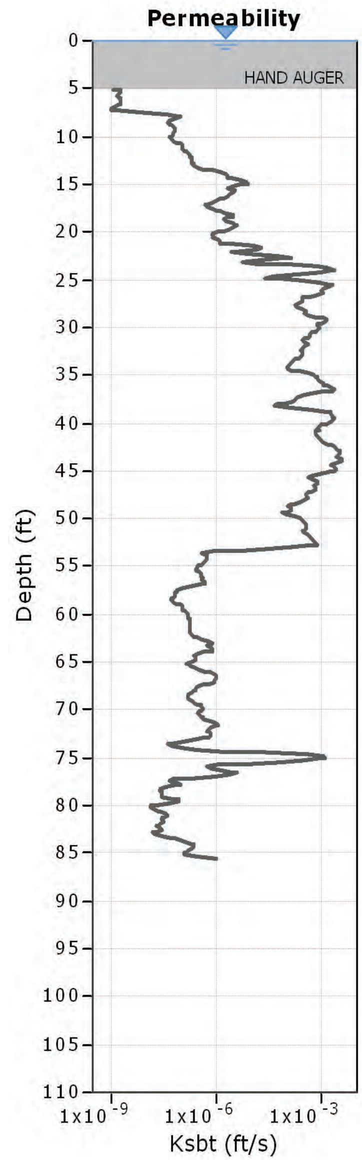
CPT: 040RI-4
Total depth: 85.63 ft, Date: 3/13/2012
Surface Elevation: 0.29 ft
Coords: X:0.00, Y:0.00
Cone Type: CPTu
Cone Operator: Gregg Drilling & Testing, Inc.

Project: **Prospect Island Tidal Habitat Restoration Project**
Location: **Solano County**

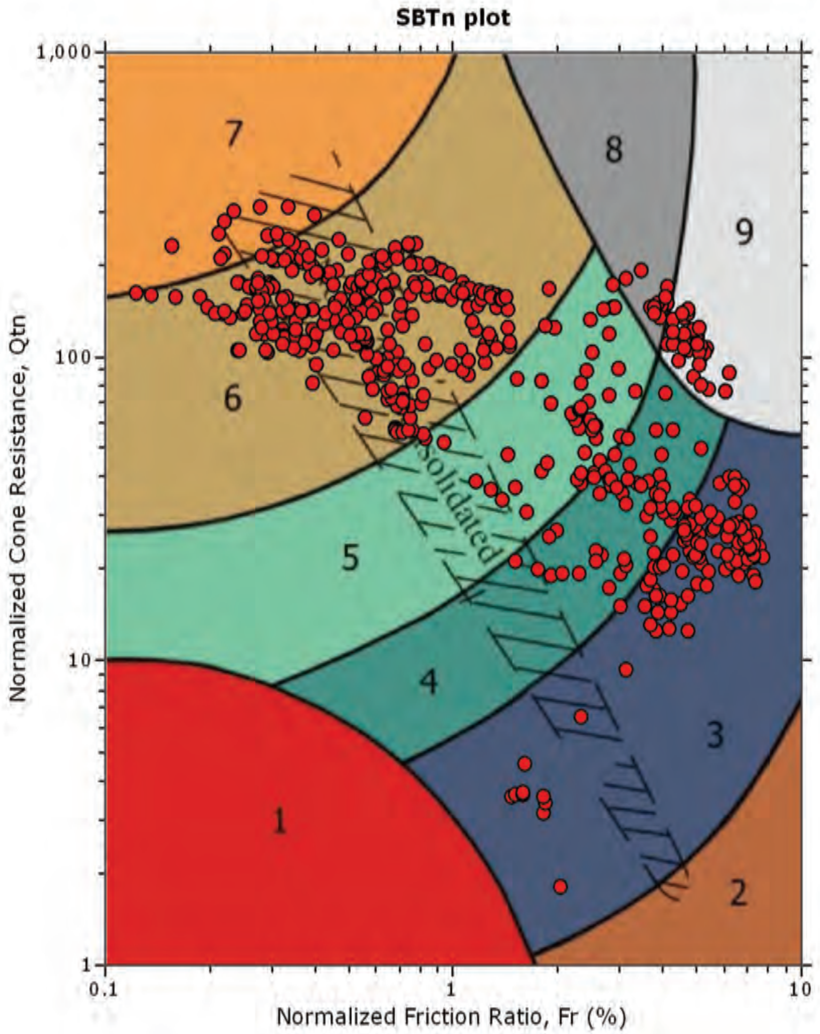


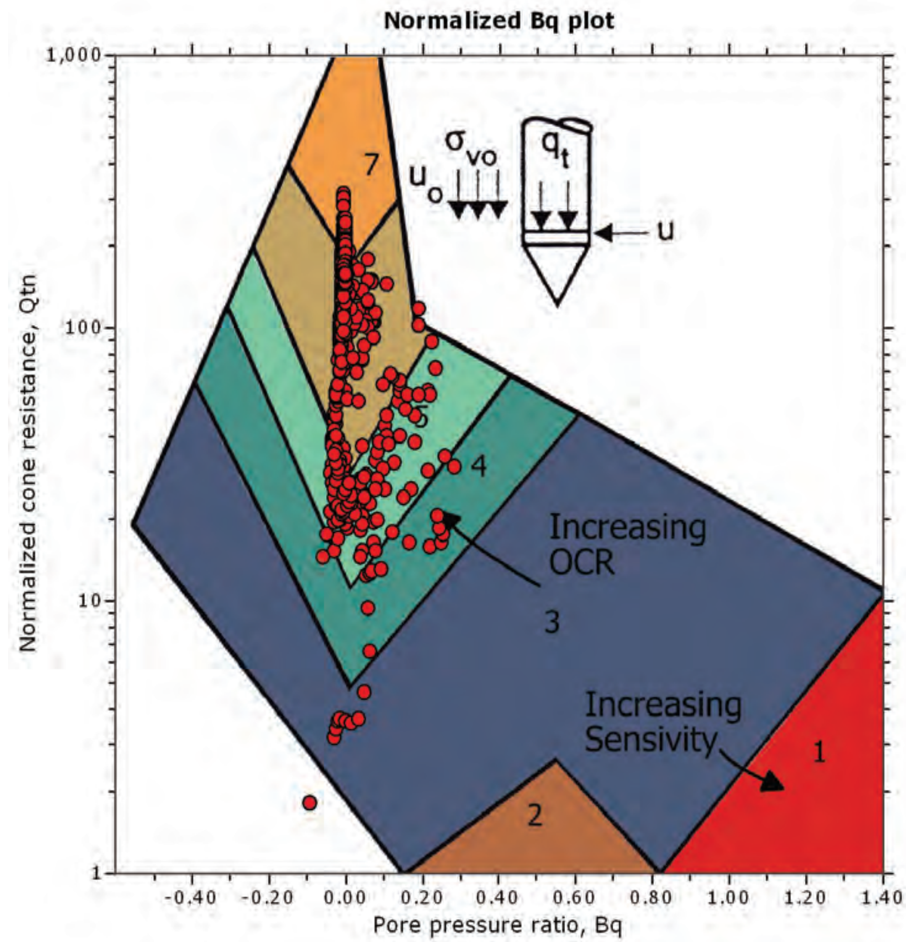
SBTn legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty clay
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to clayey sand
9. Very stiff fine grained


Permeability
HAND AUGER
Depth (ft)
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
100
105
110
1x10 -9
1x10 -6
1x10 -3
Ksbt (ft/s)

SBT - Bq plots (normalized)





SBTn legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty clay
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to clayey sand
9. Very stiff fine grained

California Department of Water Resources
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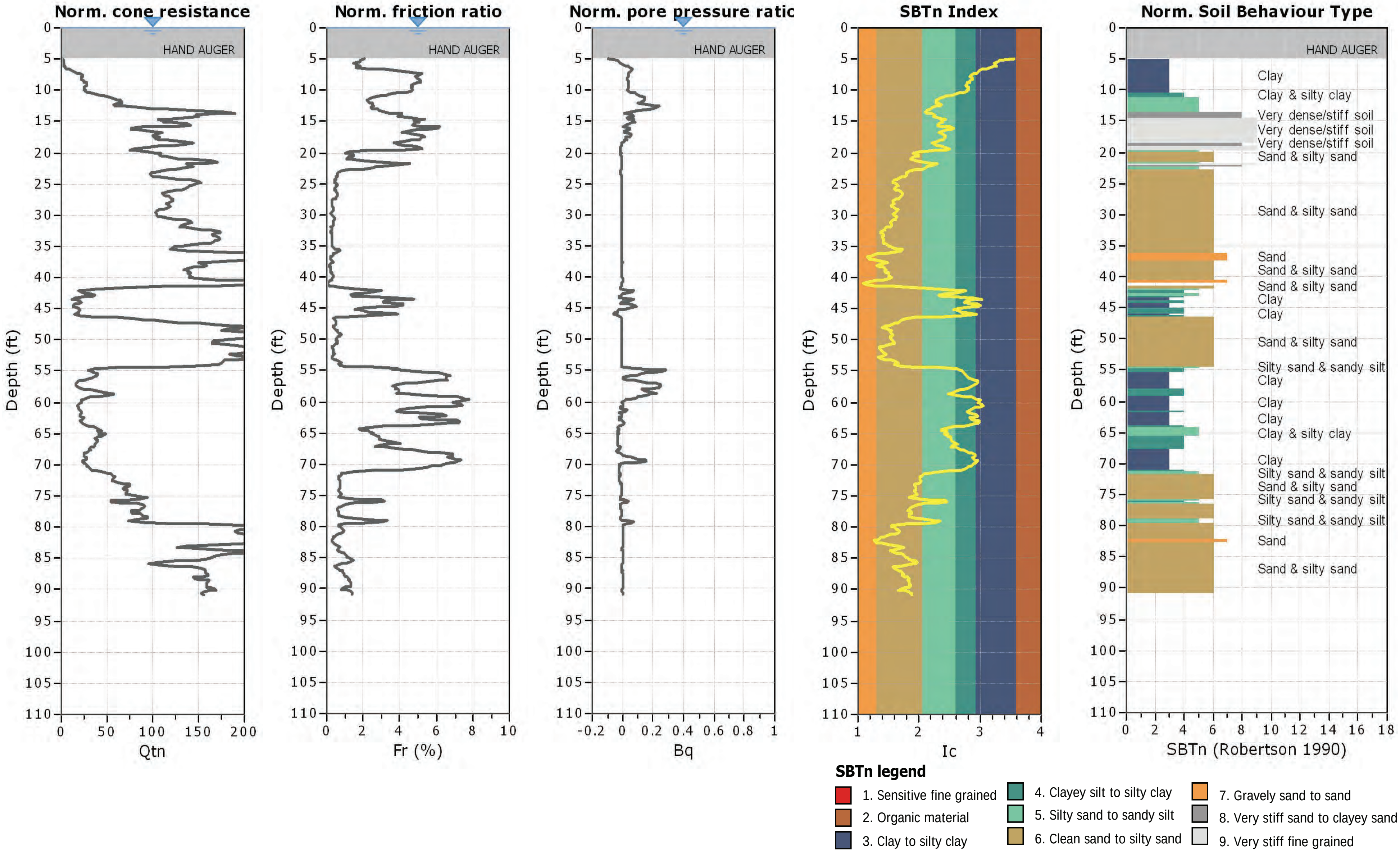
CPT: 040RI-5
Total depth: 90.88 ft, Date: 3/13/2012
Surface Elevation: -1.68 ft
Coords: X:0.00, Y:0.00
Cone Type: CPTu
Cone Operator: Gregg Drilling & Testing, Inc.

Project: **Prospect Island Tidal Habitat Restoration Project**
Location: **Solano County**



California Department of Water Resources
Division of Integrated Regional Water Management
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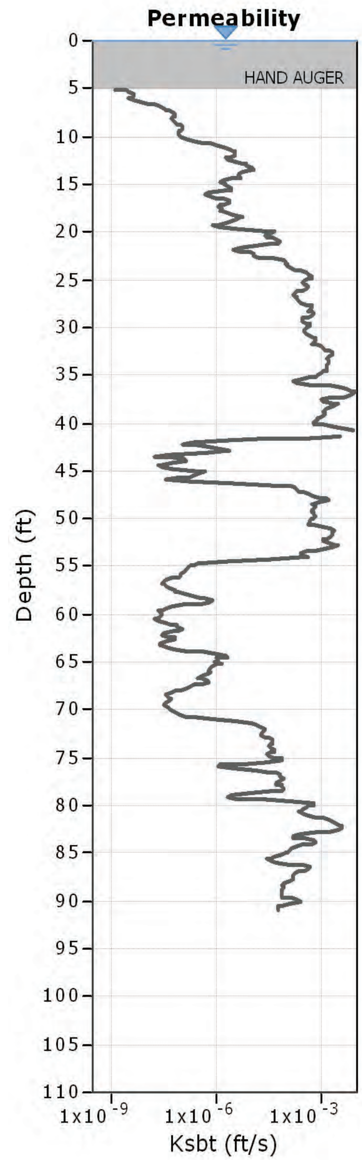
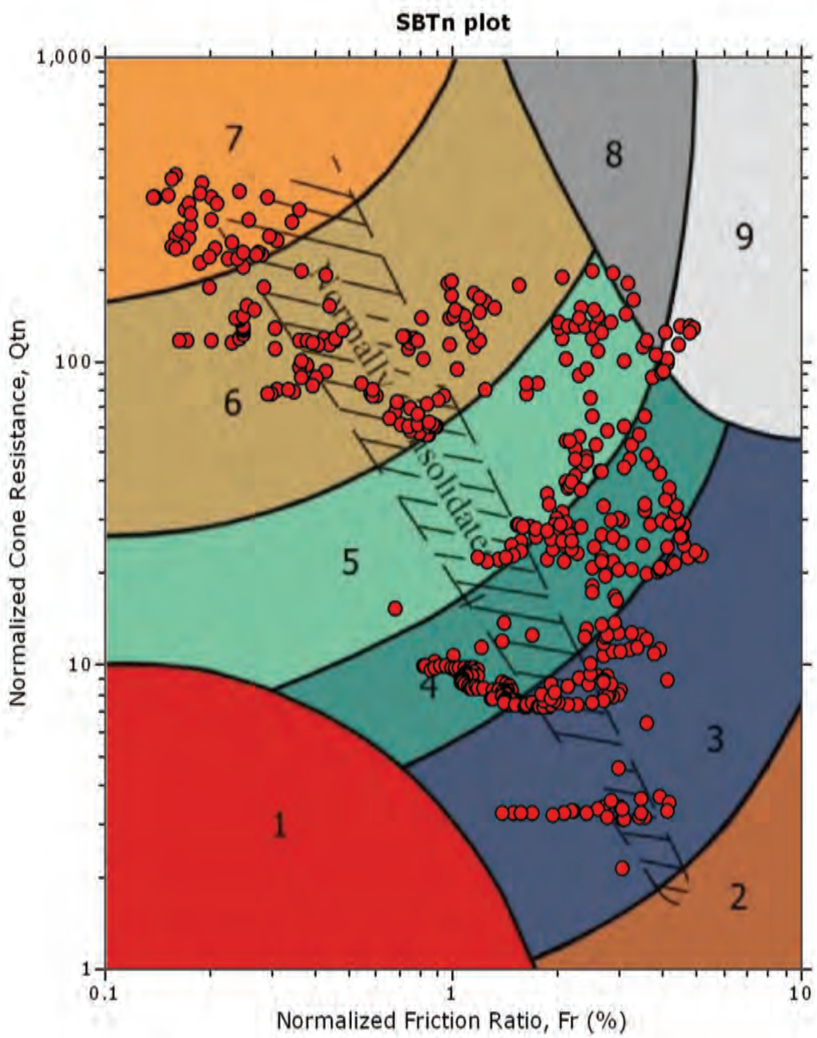
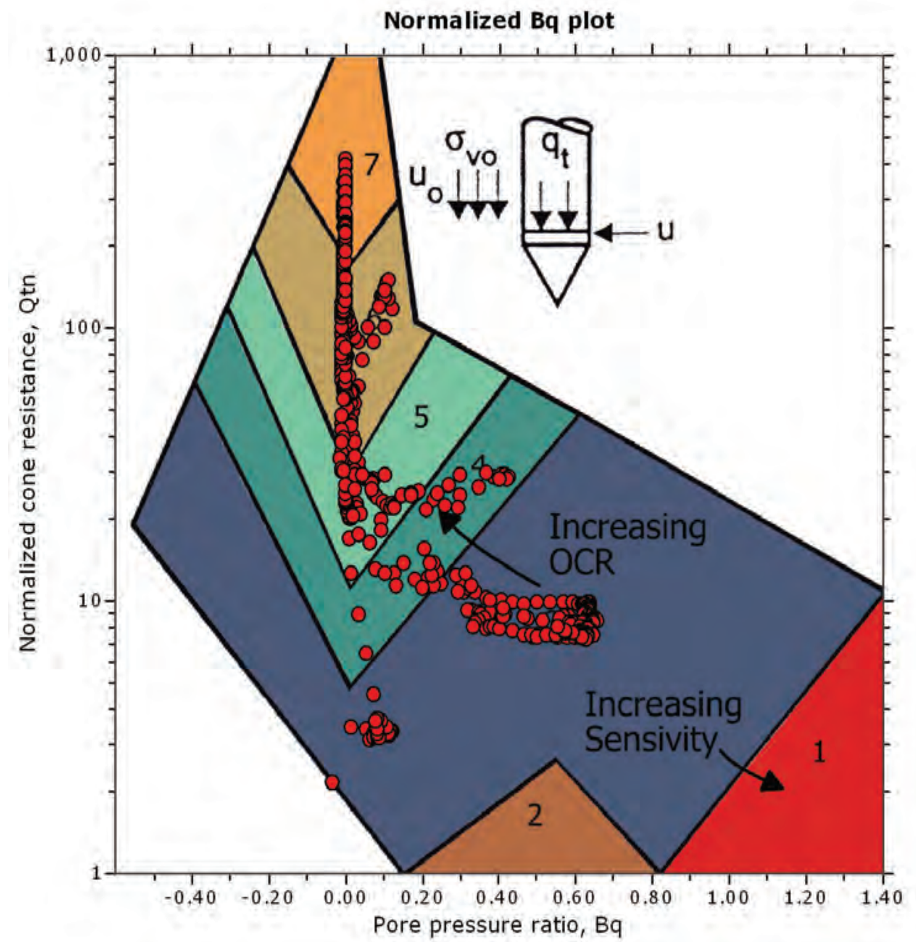
CPT: 040RI-5
Total depth: 90.88 ft, Date: 3/13/2012
Surface Elevation: -1.68 ft
Coords: X:0.00, Y:0.00
Cone Type: CPTu
Cone Operator: Gregg Drilling & Testing, Inc.

Project: **Prospect Island Tidal Habitat Restoration Project**
Location: **Solano County**



SBT - Bq plots (normalized)





SBTn legend

- 1. Sensitive fine grained
- 2. Organic material
- 3. Clay to silty clay
- 4. Clayey silt to silty clay
- 5. Silty sand to sandy silt
- 6. Clean sand to silty sand
- 7. Gravely sand to sand
- 8. Very stiff sand to clayey sand
- 9. Very stiff fine grained

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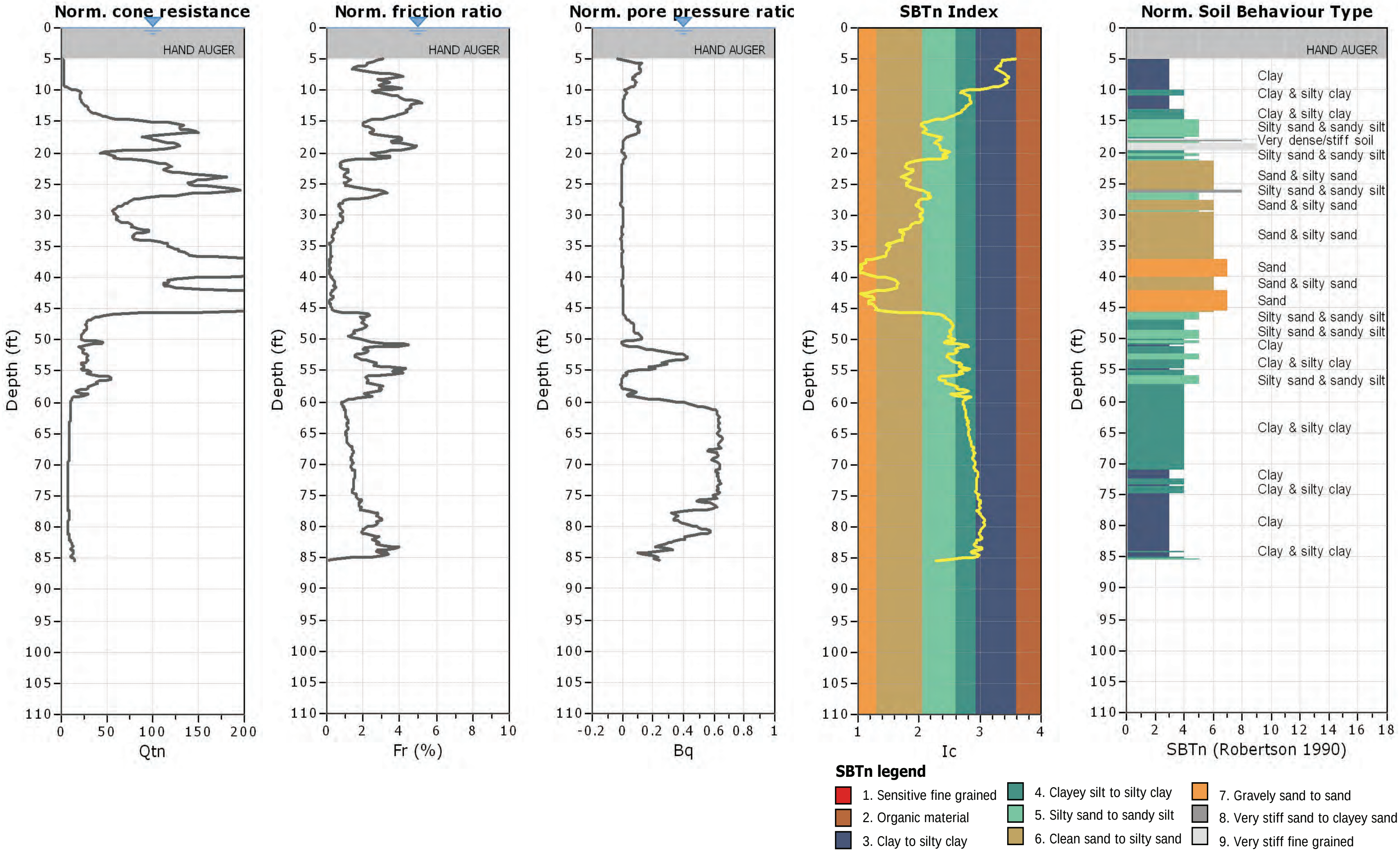
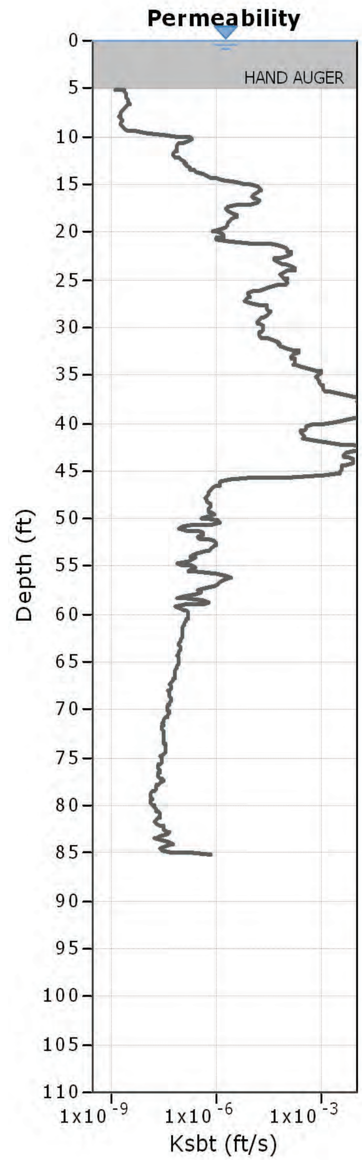
North Central Region Office
Geology and Groundwater Investigations Section

CPT: 040RIS-1
Total depth: 85.30 ft, Date: 3/13/2012
Surface Elevation: -1.69 ft
Coords: X:0.00, Y:0.00
Cone Type: CPTu
Cone Operator: Gregg Drilling & Testing, Inc.

Project: **Prospect Island Tidal Habitat Restoration Project**
Location: **Solano County**

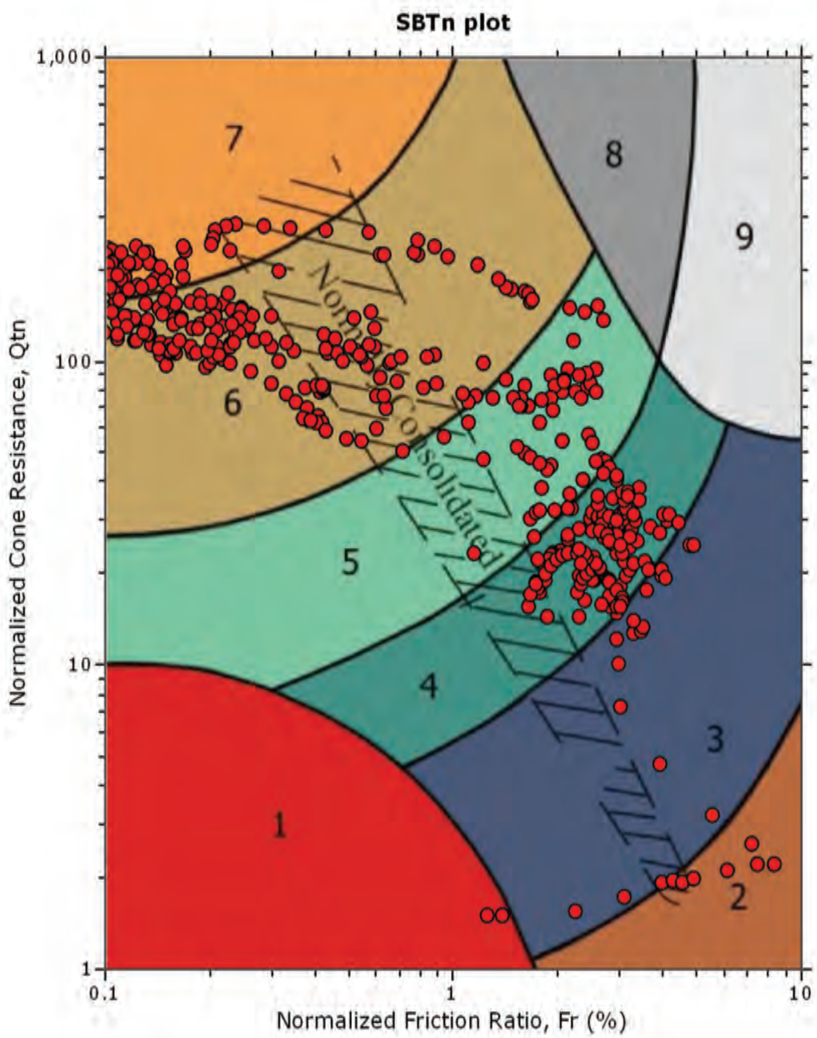


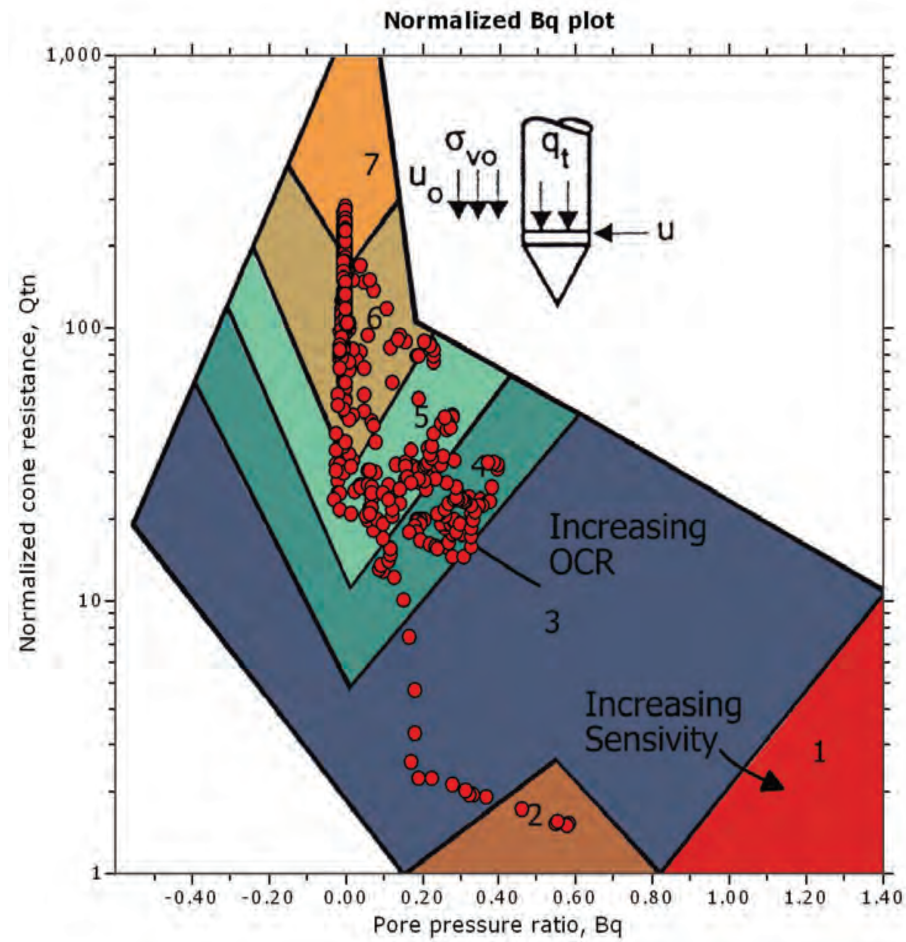

Permeability
HAND AUGER
Depth (ft)
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
100
105
110
1x10 -9
1x10 -6
1x10 -3
Ksbt (ft/s)

CPT: 040RIS-4
Total depth: 85.47 ft, Date: 3/13/2012
Surface Elevation: -1.28 ft
Coords: X:0.00, Y:0.00
Cone Type: CPTu
Cone Operator: Gregg Drilling & Testing, Inc.

Project: **Prospect Island Tidal Habitat Restoration Project**
Location: **Solano County**

SBT - Bq plots (normalized)





SBTn legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty clay
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to clayey sand
9. Very stiff fine grained

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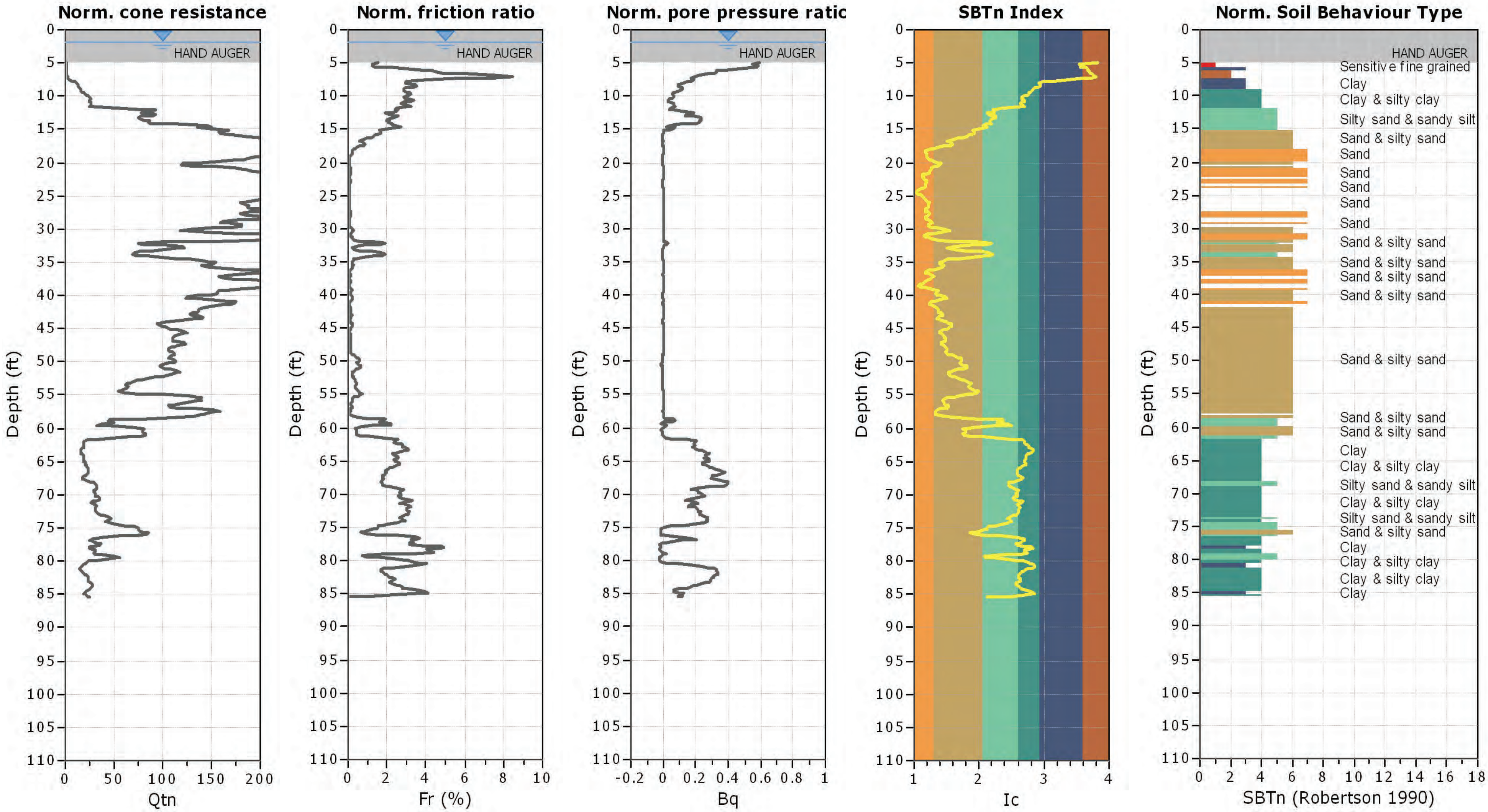
Geology and Groundwater Investigations Section

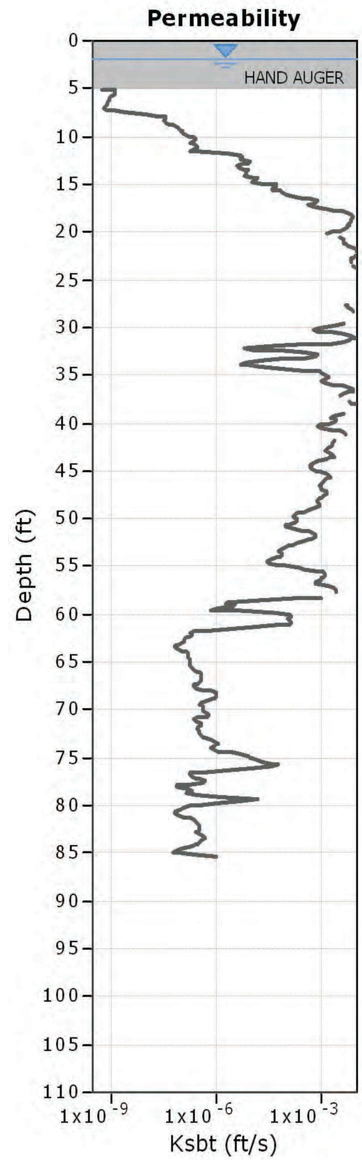
CPT: 040RIS-4
Total depth: 85.47 ft, Date: 3/13/2012
Surface Elevation: -1.28 ft
Coords: X:0.00, Y:0.00
Cone Type: CPTu
Cone Operator: Gregg Drilling & Testing, Inc.

Project: **Prospect Island Tidal Habitat Restoration Project**
Location: **Solano County**



SBTn legend

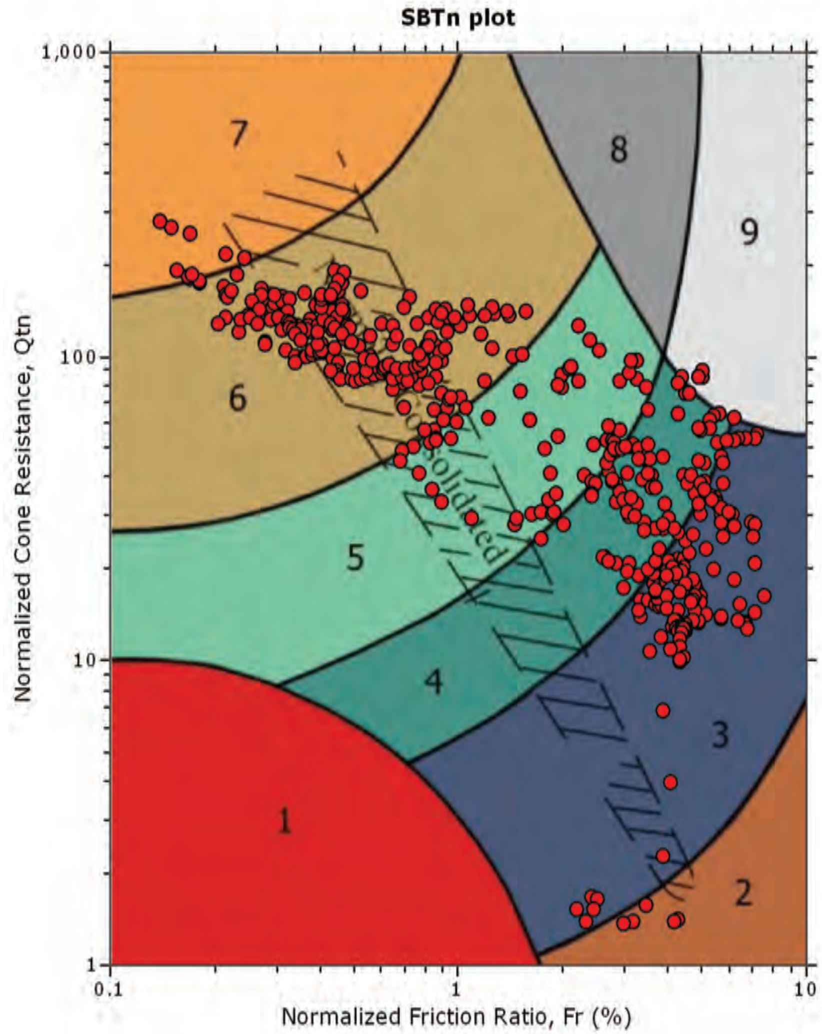
1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty clay
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to clayey sand
9. Very stiff fine grained

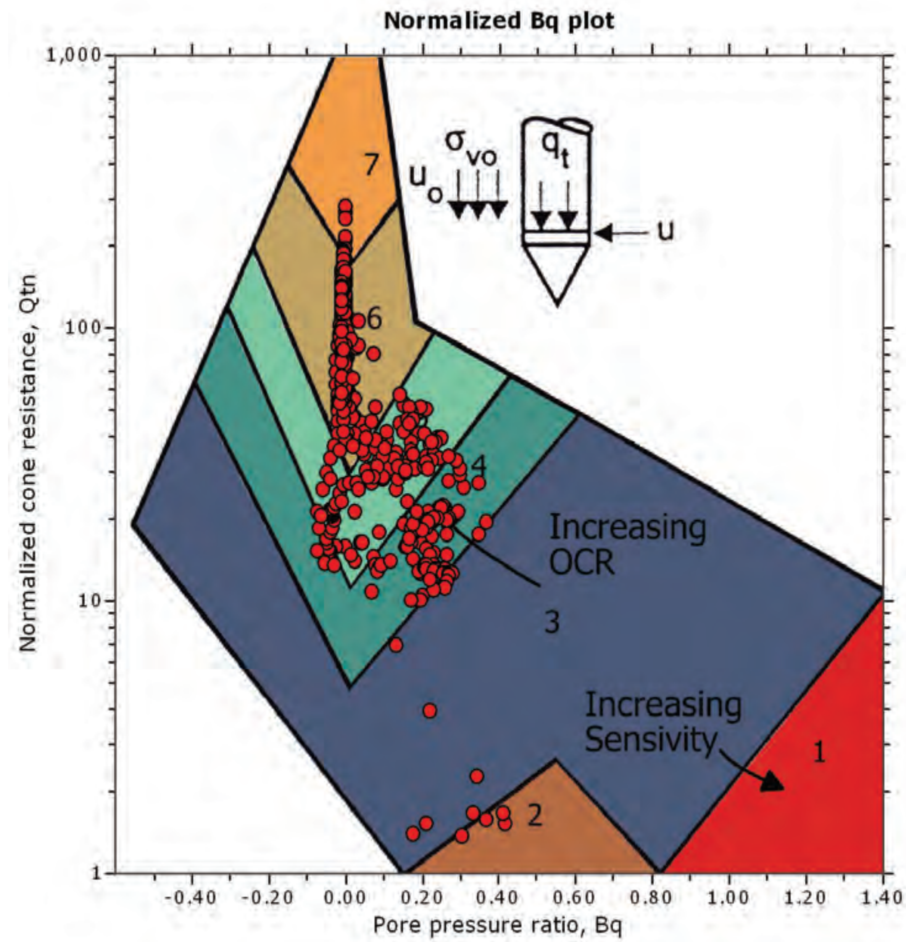

Permeability
HAND AUGER
Depth (ft)
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
100
105
110
1x10^-9
1x10^-6
1x10^-3
Ksbt (ft/s)

CPT: 040RIS-5
Total depth: 85.14 ft, Date: 3/13/2012
Surface Elevation: -0.65 ft
Coords: X:0.00, Y:0.00
Cone Type: CPTu
Cone Operator: Gregg Drilling & Testing, Inc.

Project: Prospect Island Tidal Habitat Restoration Project
Location: Solano County

SBT - Bq plots (normalized)





SBTn legend

- 1. Sensitive fine grained
- 2. Organic material
- 3. Clay to silty clay
- 4. Clayey silt to silty clay
- 5. Silty sand to sandy silt
- 6. Clean sand to silty sand
- 7. Gravely sand to sand
- 8. Very stiff sand to clayey sand
- 9. Very stiff fine grained

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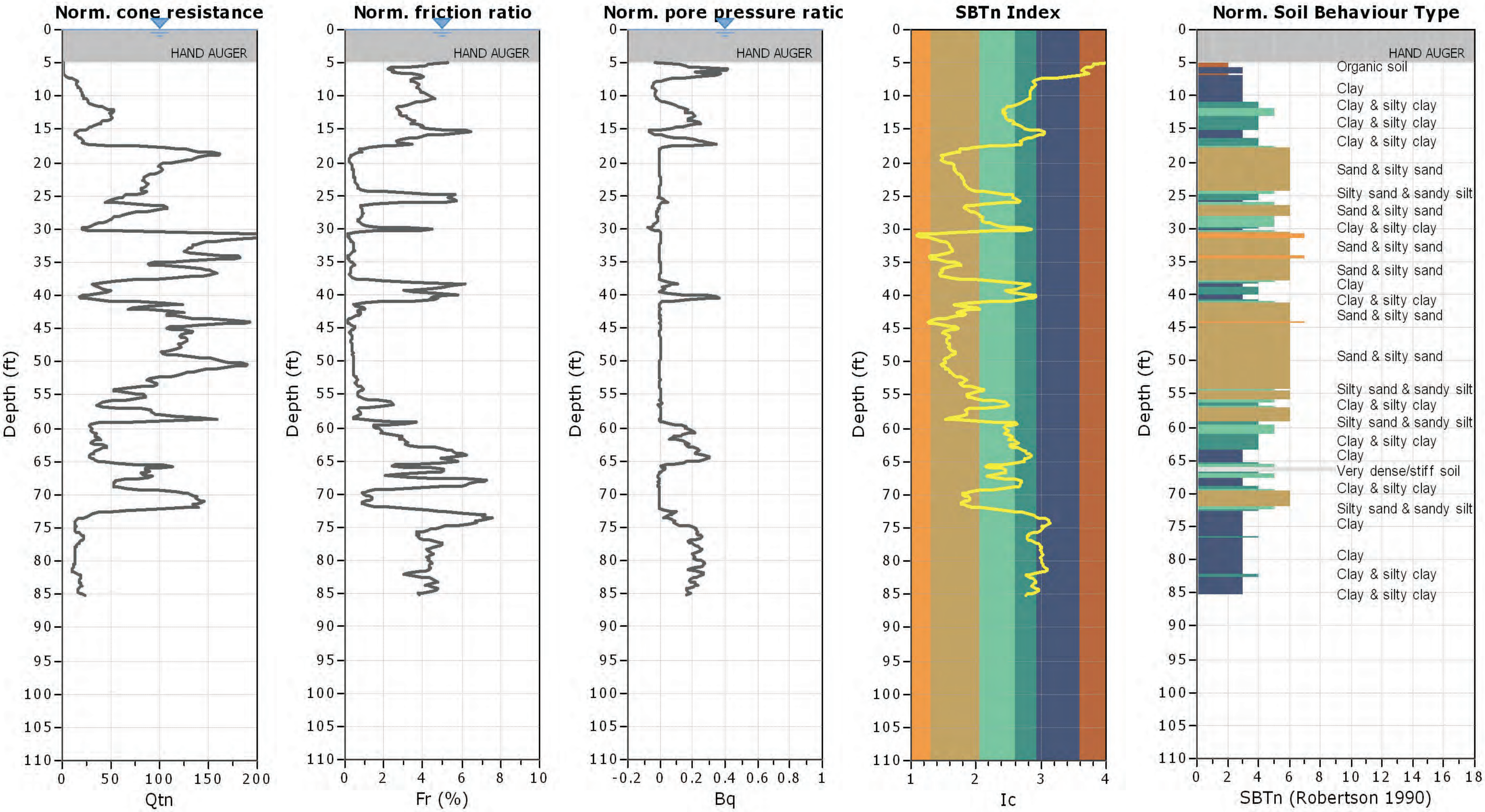
North Central Region Office
Geology and Groundwater Investigations Section

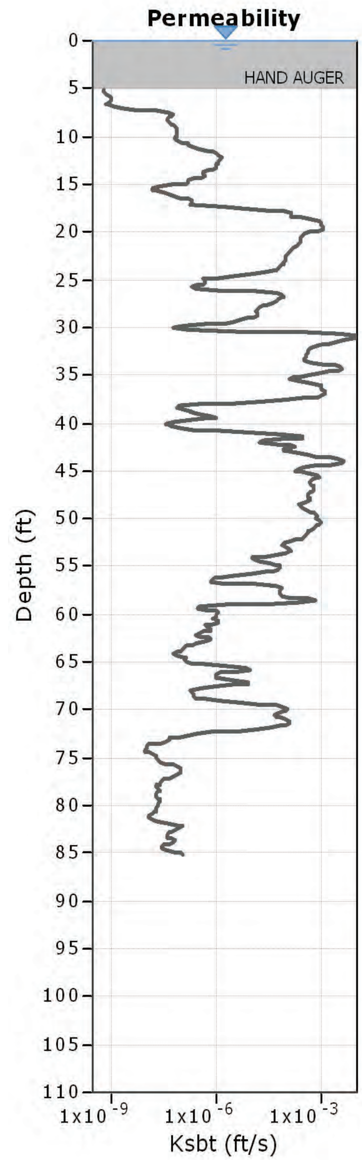
CPT: 040RIS-5
Total depth: 85.14 ft, Date: 3/13/2012
Surface Elevation: -0.65 ft
Coords: X:0.00, Y:0.00
Cone Type: CPTu
Cone Operator: Gregg Drilling & Testing, Inc.

Project: **Prospect Island Tidal Habitat Restoration Project**
Location: **Solano County**

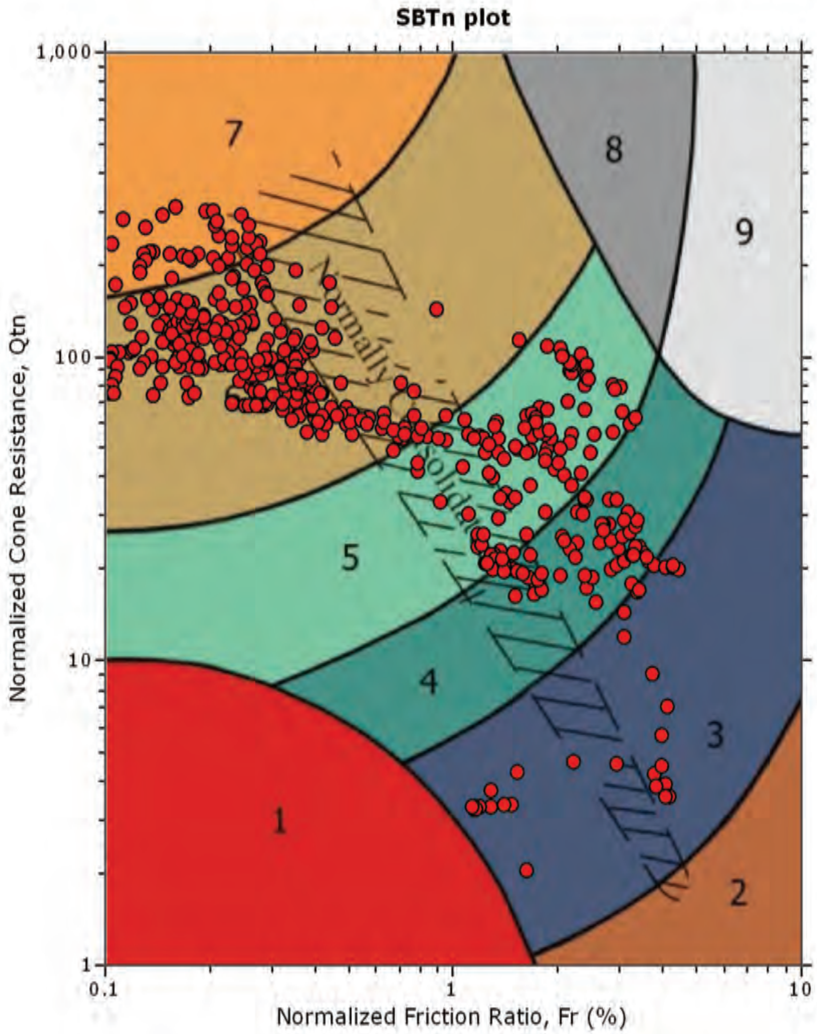


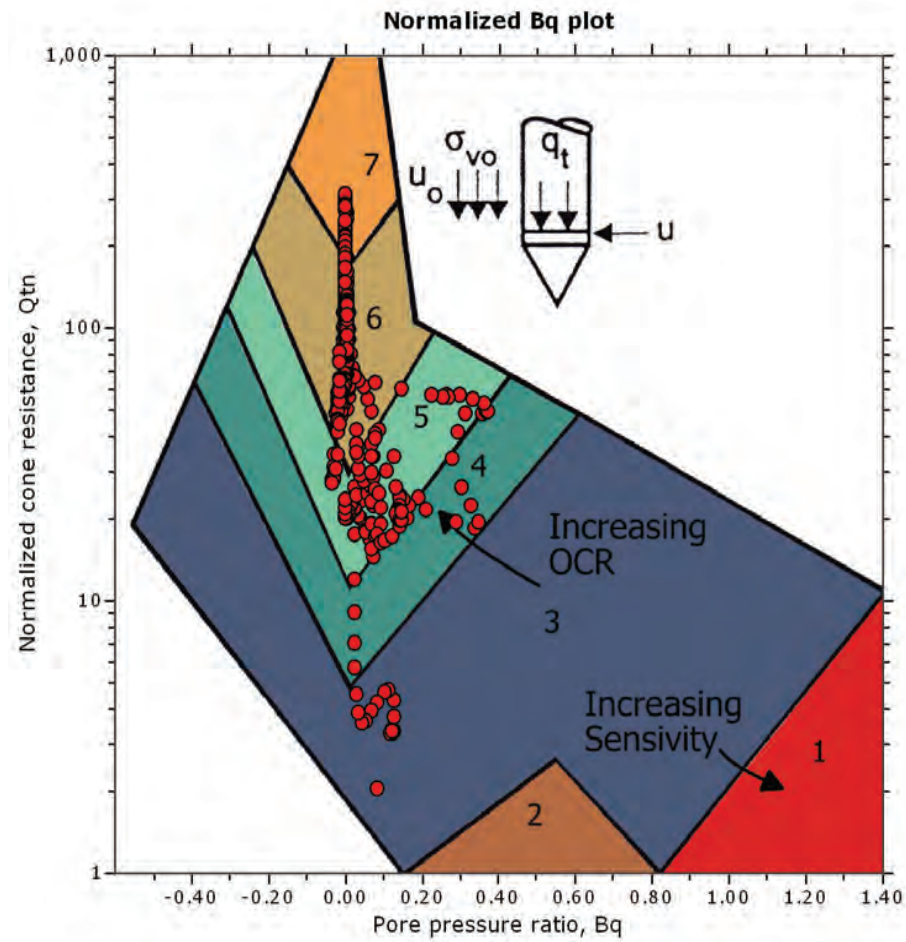
SBTn legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty clay
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to clayey sand
9. Very stiff fine grained


Permeability
HAND AUGER
Depth (ft)
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
100
105
110
1x10 -9
1x10 -6
1x10 -3
Ksbt (ft/s)

SBT - Bq plots (normalized)





SBTn legend

- 1. Sensitive fine grained
- 2. Organic material
- 3. Clay to silty clay
- 4. Clayey silt to silty clay
- 5. Silty sand to sandy silt
- 6. Clean sand to silty sand
- 7. Gravely sand to sand
- 8. Very stiff sand to clayey sand
- 9. Very stiff fine grained

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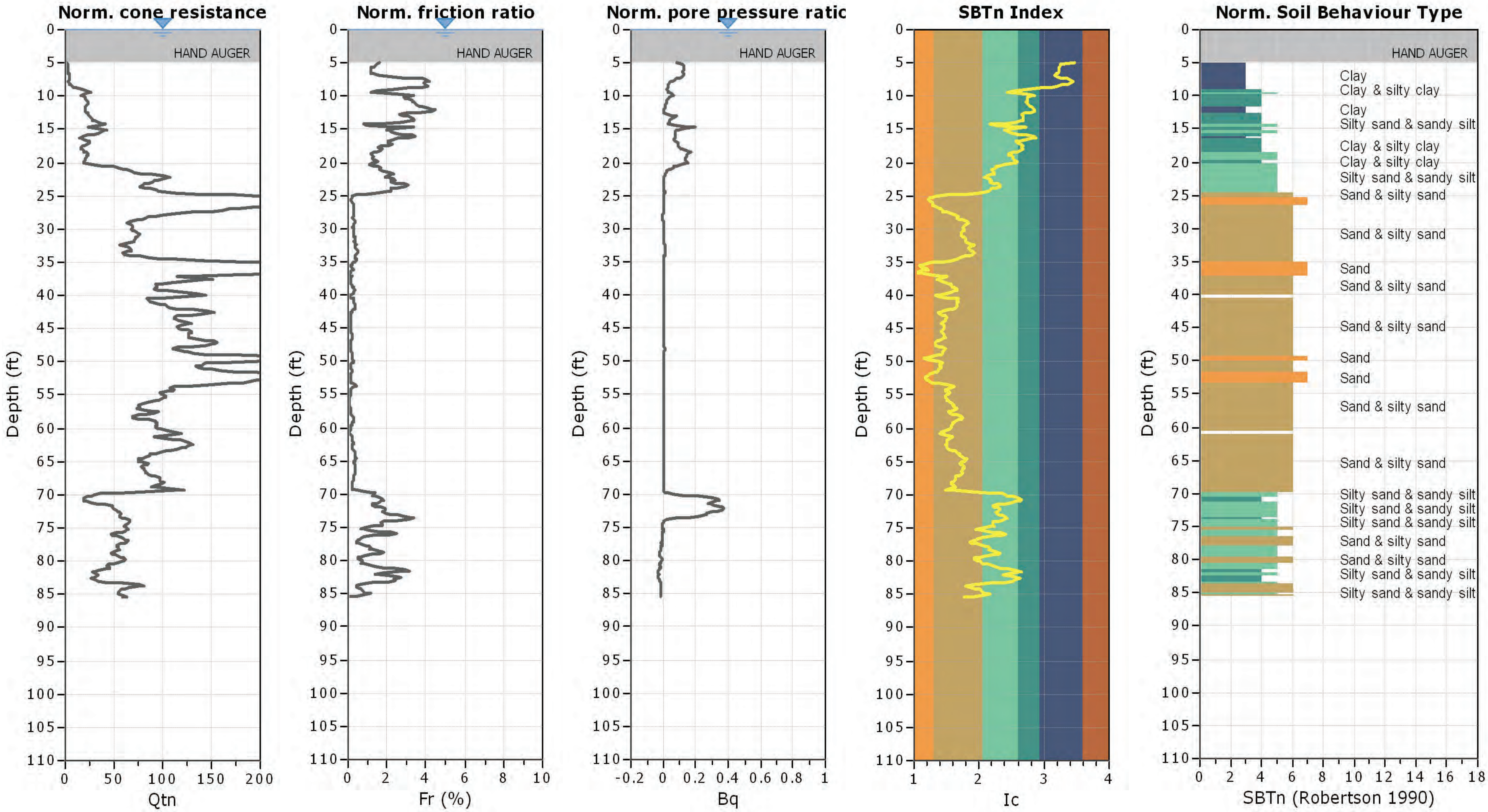
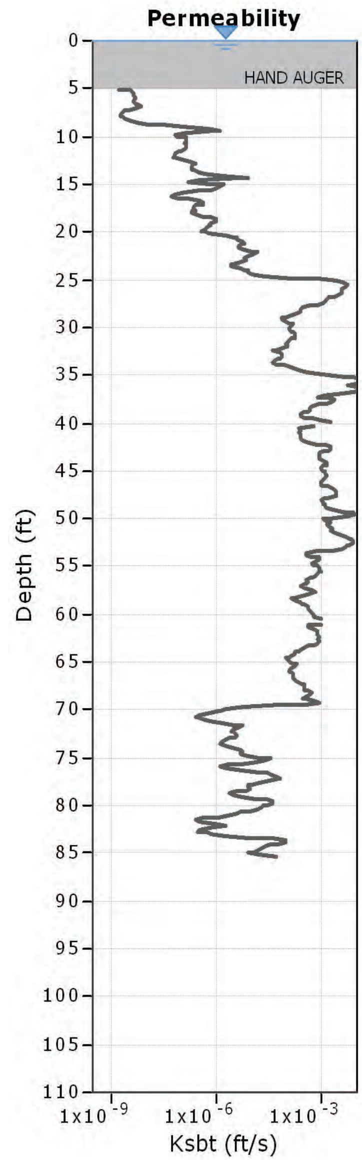
CPT: 040RIS-6
Total depth: 85.47 ft, Date: 3/13/2012
Surface Elevation: -0.63 ft
Coords: X:0.00, Y:0.00
Cone Type: CPTu
Cone Operator: Gregg Drilling & Testing, Inc.

Project: **Prospect Island Tidal Habitat Restoration Project**
Location: **Solano County**

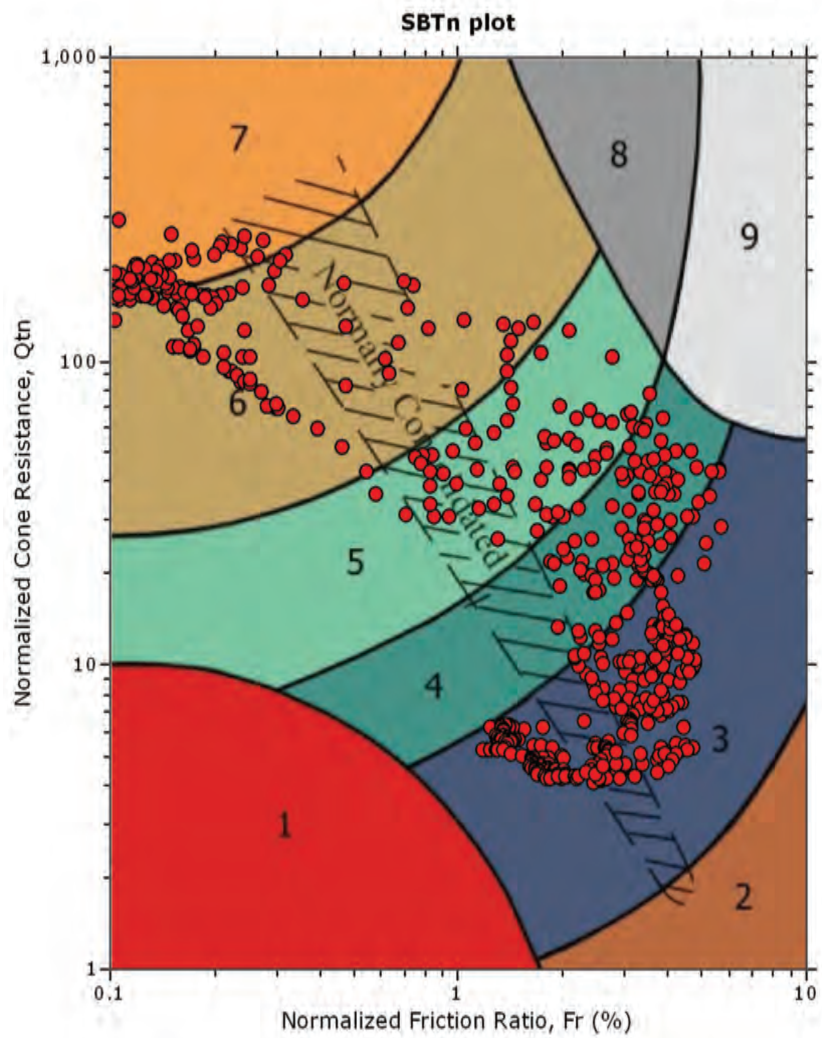


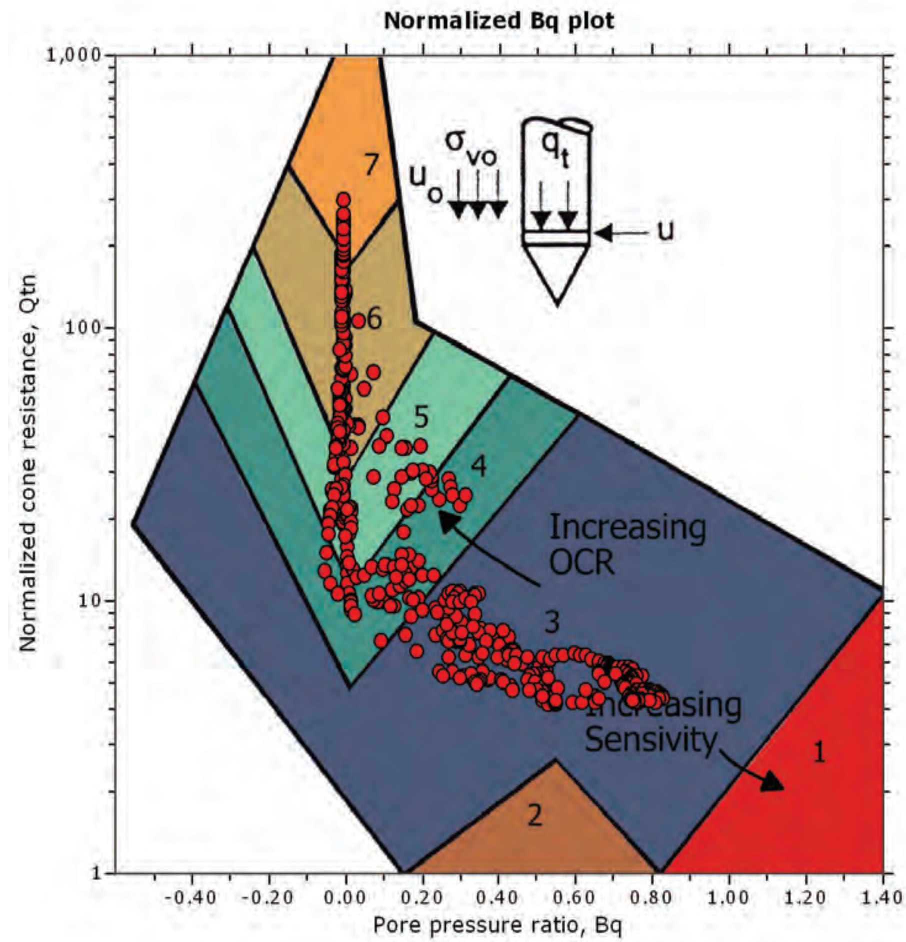
SBTn legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty clay
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to clayey sand
9. Very stiff fine grained


Permeability
HAND AUGER
Depth (ft)
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
100
105
110
1x10 -9
1x10 -6
1x10 -3
Ksbt (ft/s)

SBT - Bq plots (normalized)





SBTn legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty clay
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to clayey sand
9. Very stiff fine grained

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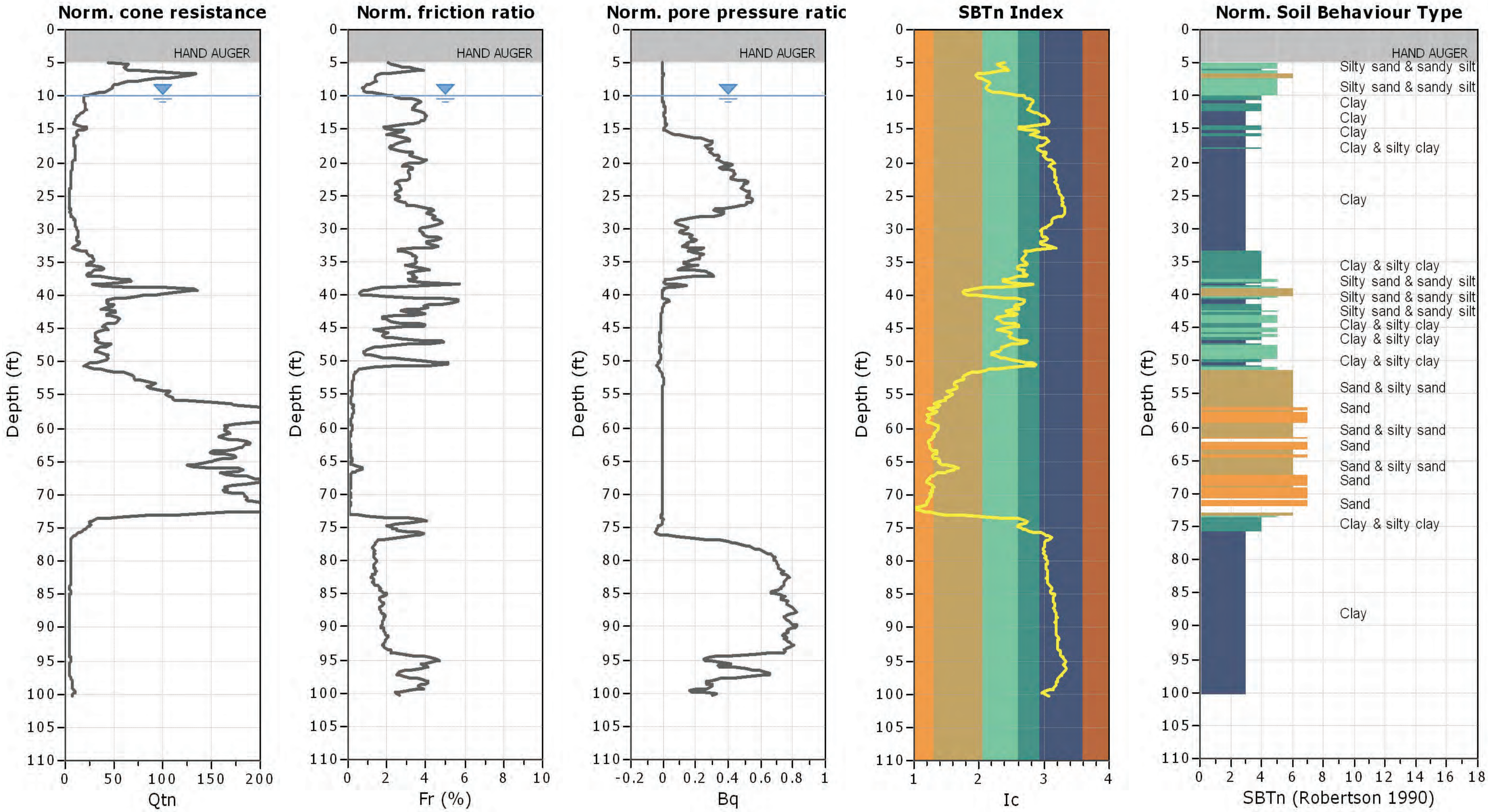
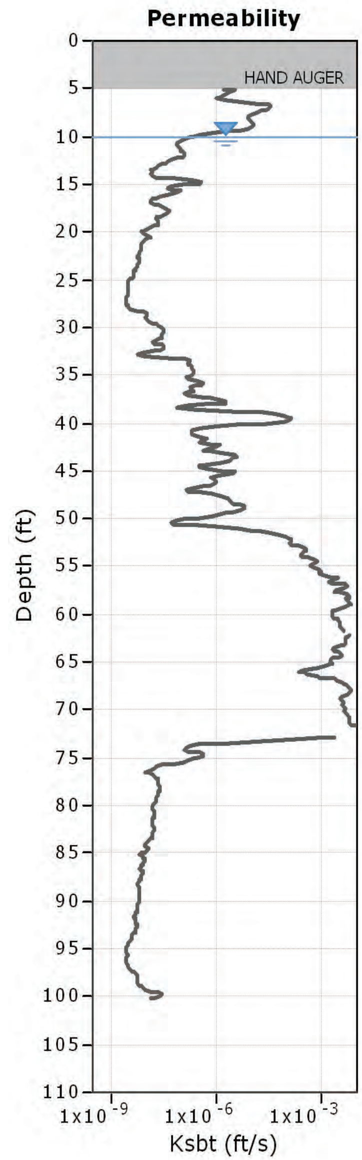
CPT: 141cpi1
Total depth: 100.23 ft, Date: 3/13/2012
Surface Elevation: 14.97 ft
Coords: X:0.00, Y:0.00
Cone Type: CPTu
Cone Operator: Gregg Drilling & Testing, Inc.

Project: Prospect Island Tidal Habitat Restoration Project
Location: Solano County



SBTn legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty clay
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to clayey sand
9. Very stiff fine grained

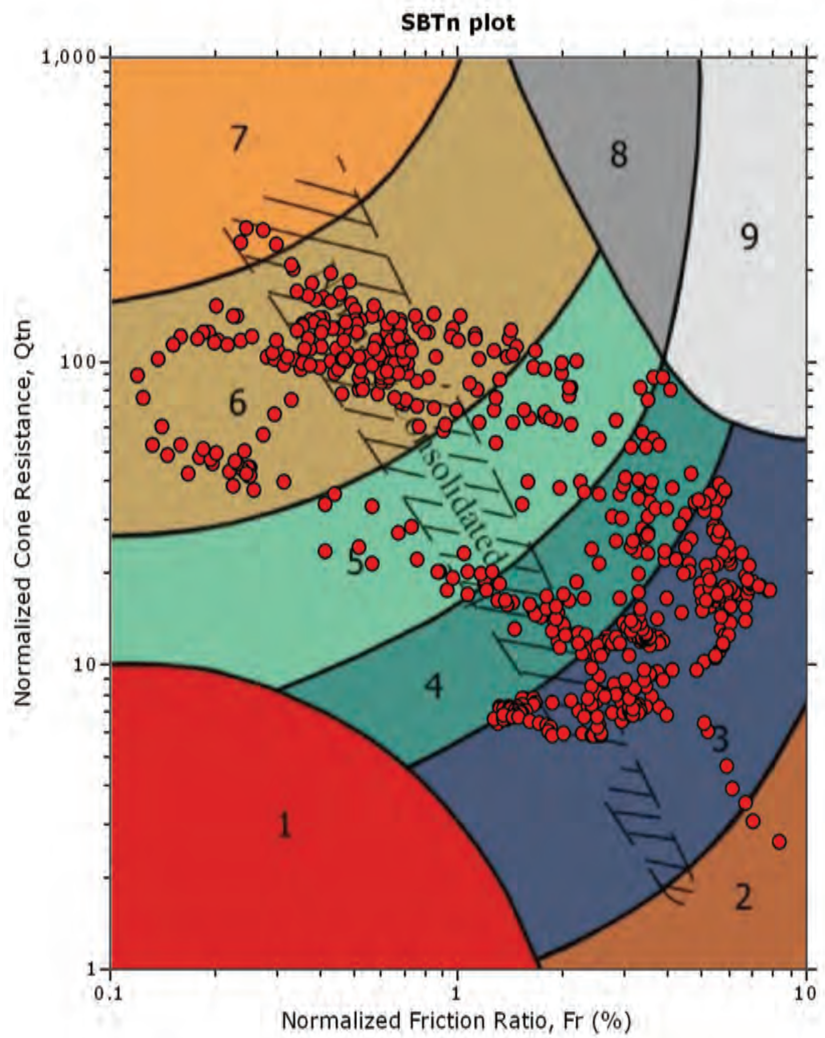

Permeability
HAND AUGER
Depth (ft)
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
100
105
110
1x10 -9
1x10 -6
1x10 -3
Ksbt (ft/s)

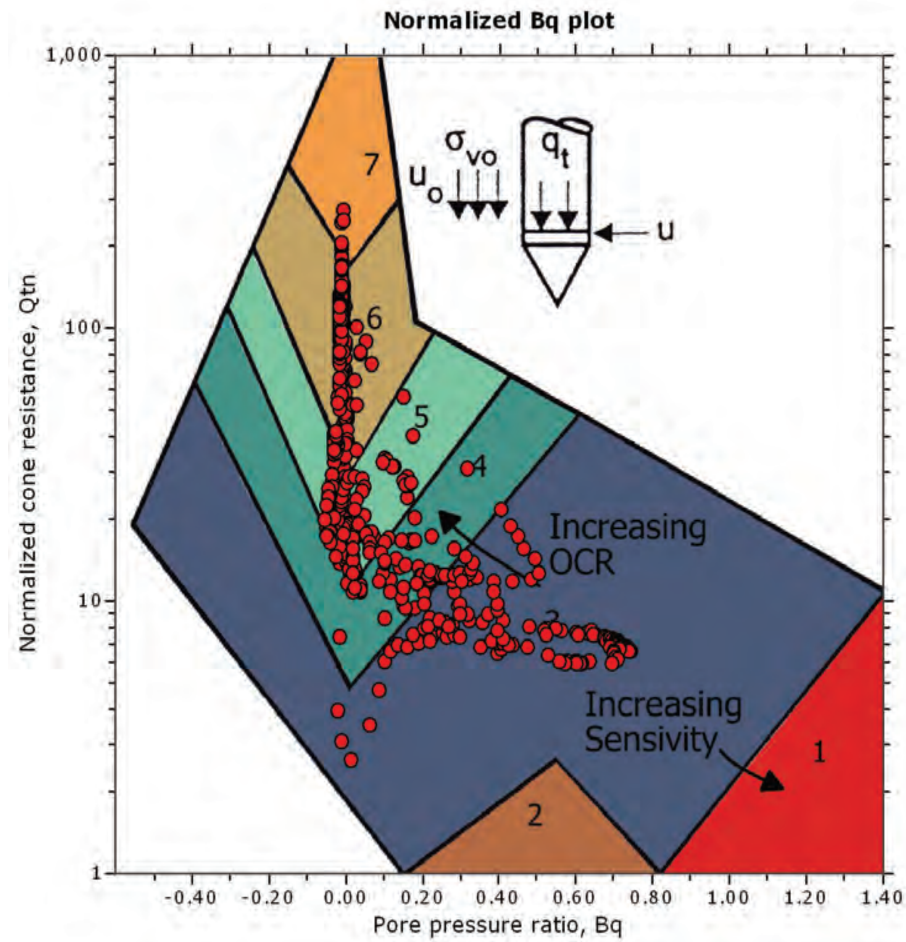
California Department of Water Resources
Division of Integrated Regional Water Management
North Central Region Office
Geology and Groundwater Investigations Section

CPT: 141cpi10
Total depth: 100.23 ft, Date: 3/13/2012
Surface Elevation: 14.83 ft
Coords: X:0.00, Y:0.00
Cone Type: CPTu
Cone Operator: Gregg Drilling & Testing, Inc.

Project: **Prospect Island Tidal Habitat Restoration Project**
Location: **Solano County**

SBT - Bq plots (normalized)





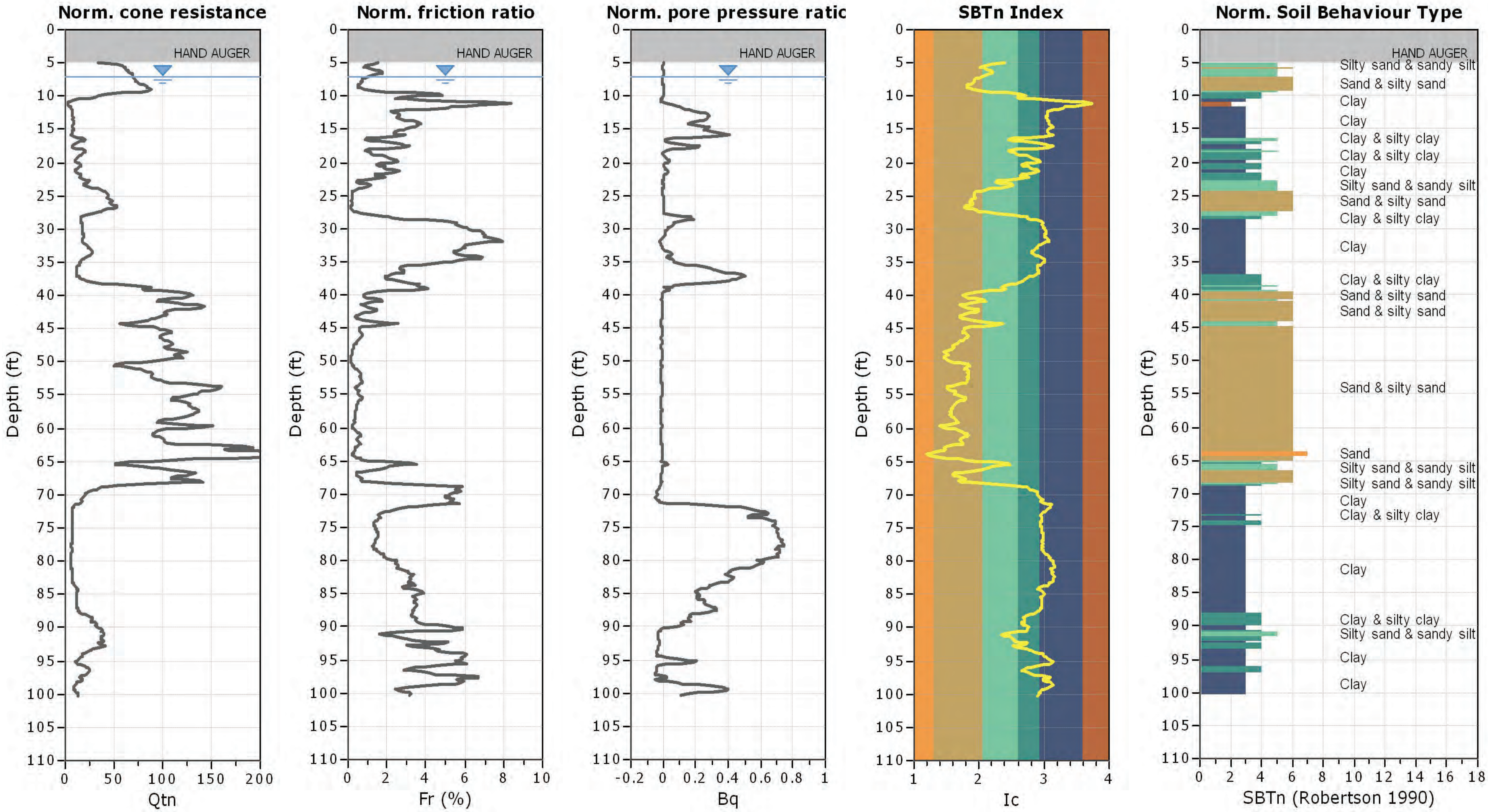
SBTn legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty clay
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to clayey sand
9. Very stiff fine grained

California Department of Water Resources
Division of Integrated Regional Water Management
North Central Region Office
Geology and Groundwater Investigations Section

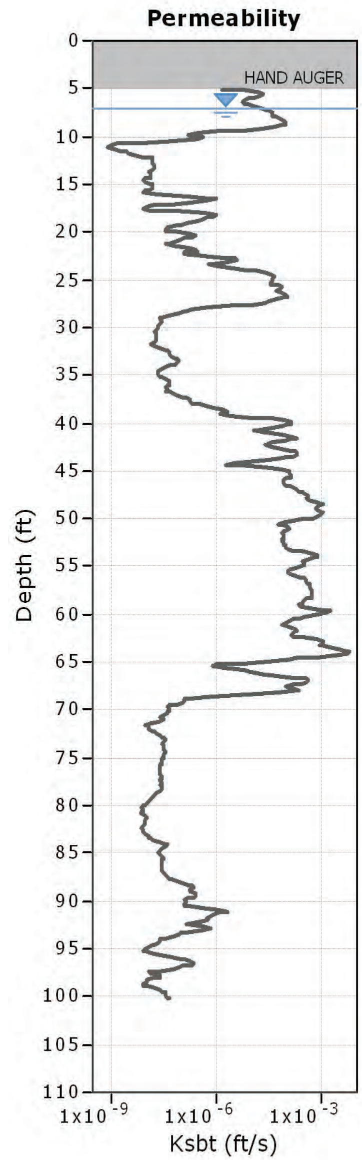
CPT: 141cpi10
Total depth: 100.23 ft, Date: 3/13/2012
Surface Elevation: 14.83 ft
Coords: X:0.00, Y:0.00
Cone Type: CPTu
Cone Operator: Gregg Drilling & Testing, Inc.

Project: **Prospect Island Tidal Habitat Restoration Project**
Location: **Solano County**

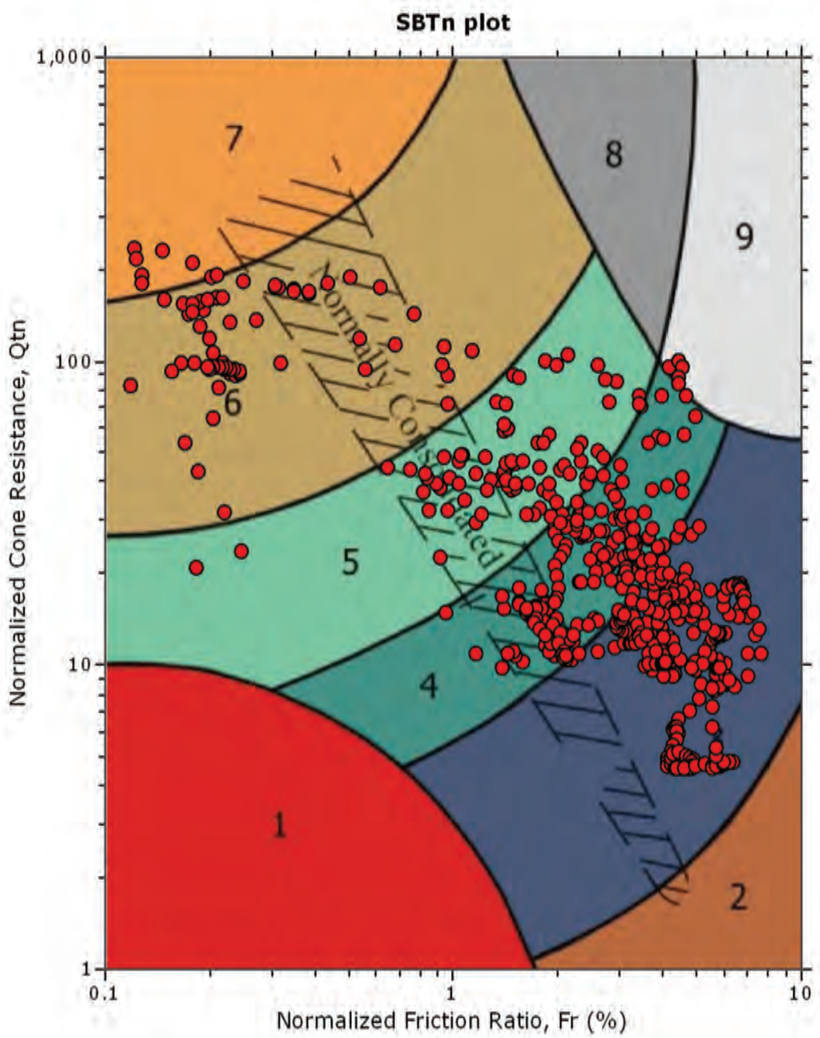


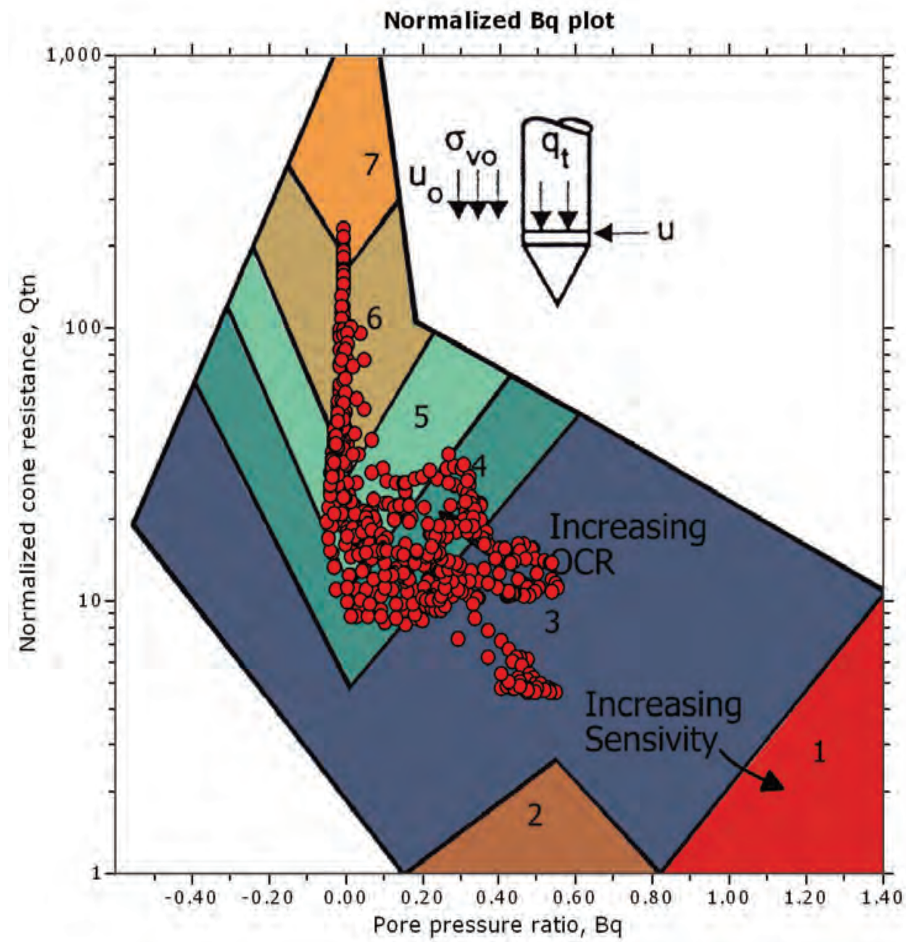
SBTn legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty clay
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to clayey sand
9. Very stiff fine grained


Permeability
HAND AUGER
Depth (ft)
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
100
105
110
1x10 -9
1x10 -6
1x10 -3
Ksbt (ft/s)

SBT - Bq plots (normalized)





SBTn legend

1. Sensitive fine grained	4. Clayey silt to silty clay	7. Gravely sand to sand
2. Organic material	5. Silty sand to sandy silt	8. Very stiff sand to clayey sand
3. Clay to silty clay	6. Clean sand to silty sand	9. Very stiff fine grained

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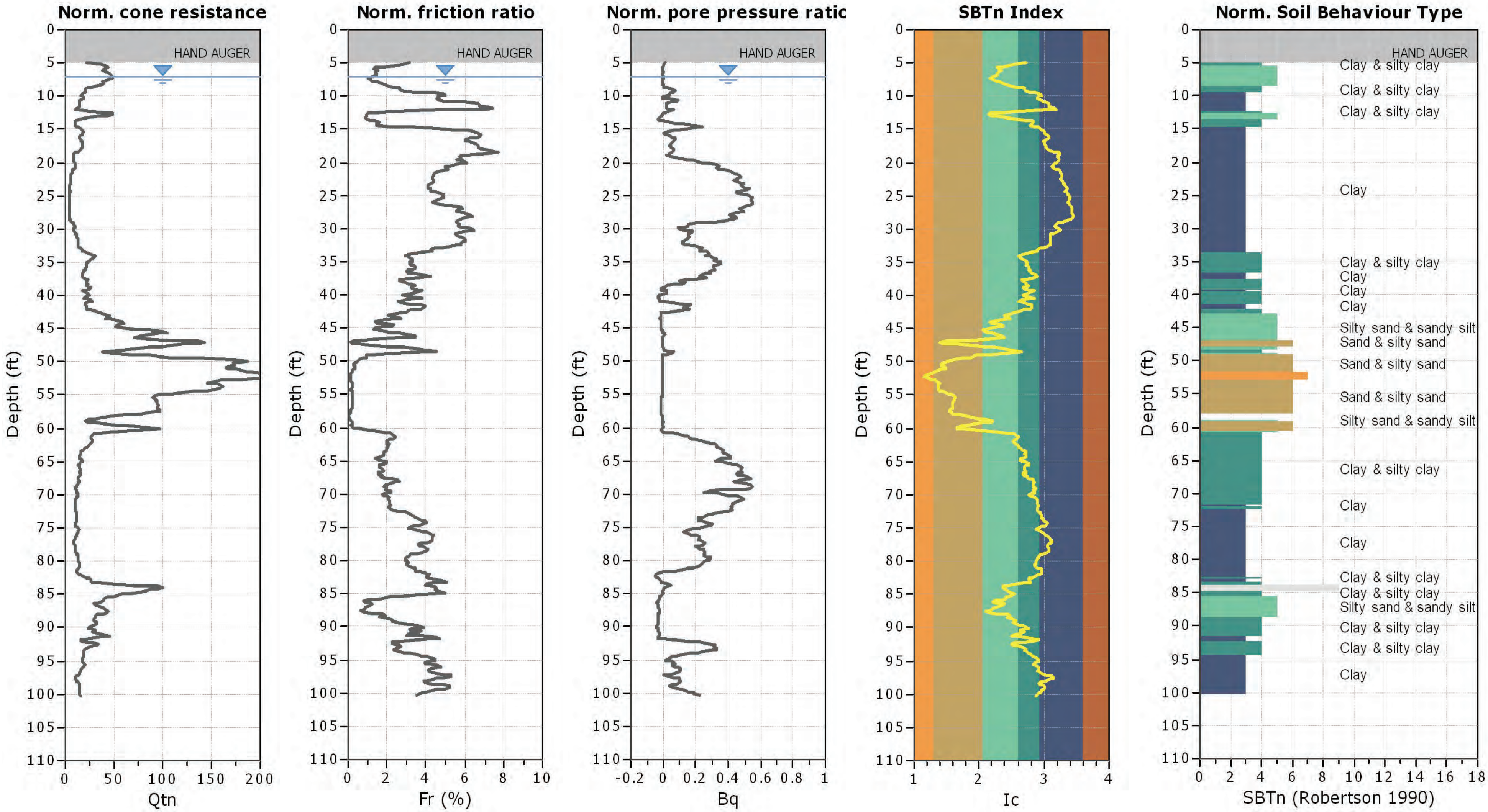
North Central Region Office
Geology and Groundwater Investigations Section

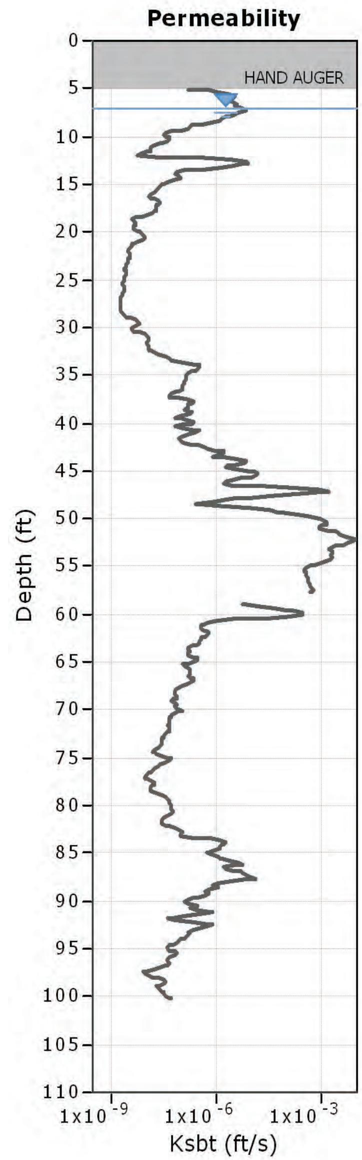
CPT: 141cpi2
Total depth: 100.23 ft, Date: 3/13/2012
Surface Elevation: 12.98 ft
Coords: X:0.00, Y:0.00
Cone Type: CPTu
Cone Operator: Gregg Drilling & Testing, Inc.

Project: **Prospect Island Tidal Habitat Restoration Project**
Location: **Solano County**

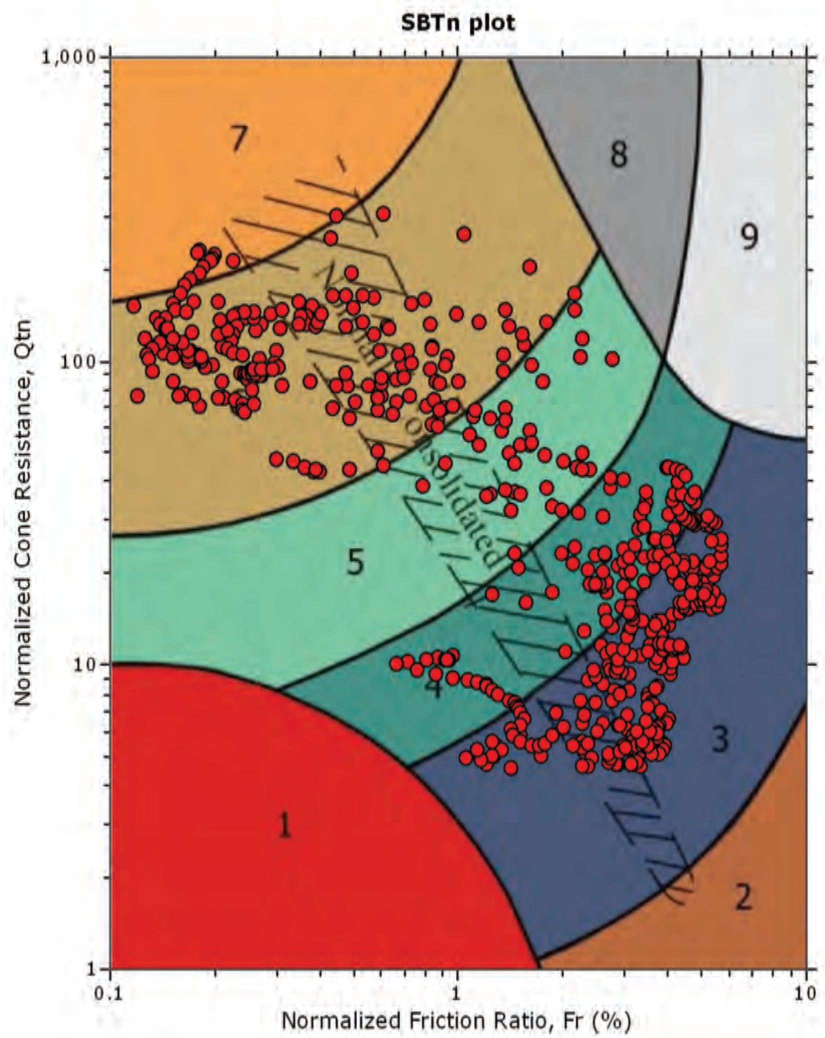


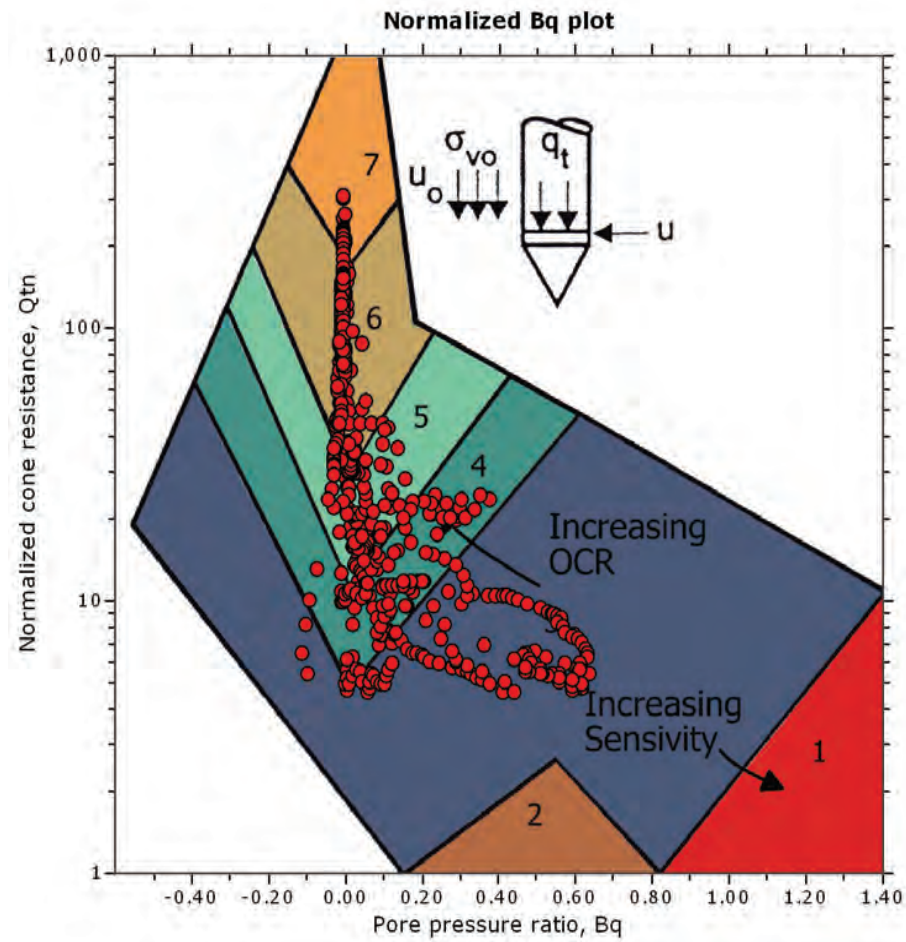
SBTn legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty clay
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to clayey sand
9. Very stiff fine grained


Permeability
HAND AUGER
Depth (ft)
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
100
105
110
1x10 -9
1x10 -6
1x10 -3
Ksbt (ft/s)

SBT - Bq plots (normalized)



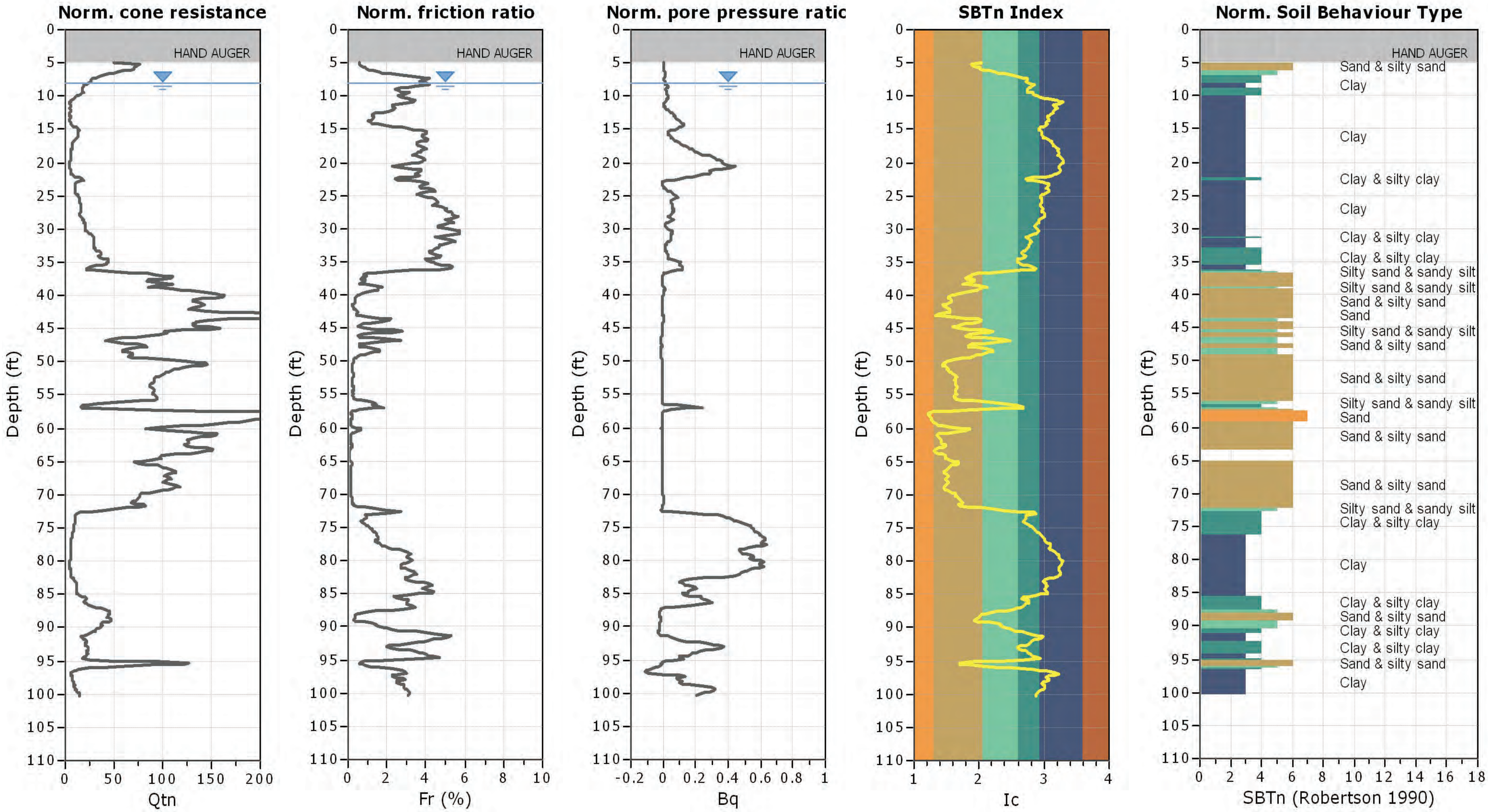


SBTn legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty clay
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to clayey sand
9. Very stiff fine grained

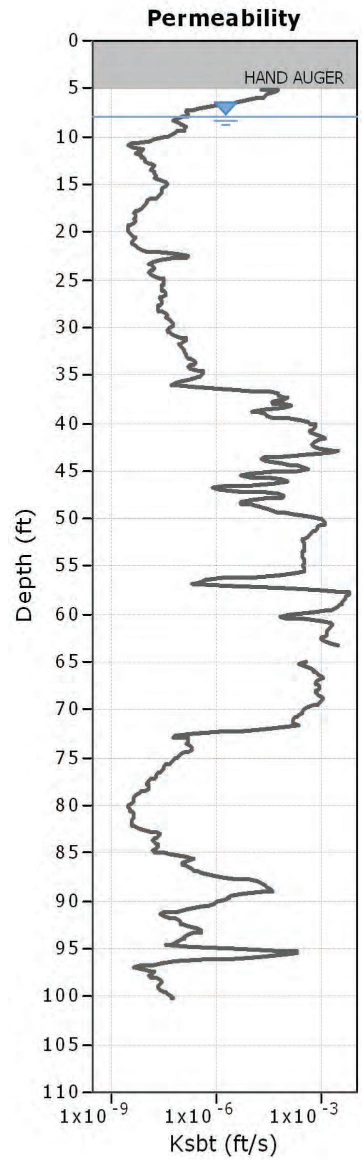
CPT: 141cpi3
Total depth: 100.23 ft, Date: 3/13/2012
Surface Elevation: 13.93 ft
Coords: X:0.00, Y:0.00
Cone Type: CPTu
Cone Operator: Gregg Drilling & Testing, Inc.

Project: **Prospect Island Tidal Habitat Restoration Project**
Location: **Solano County**



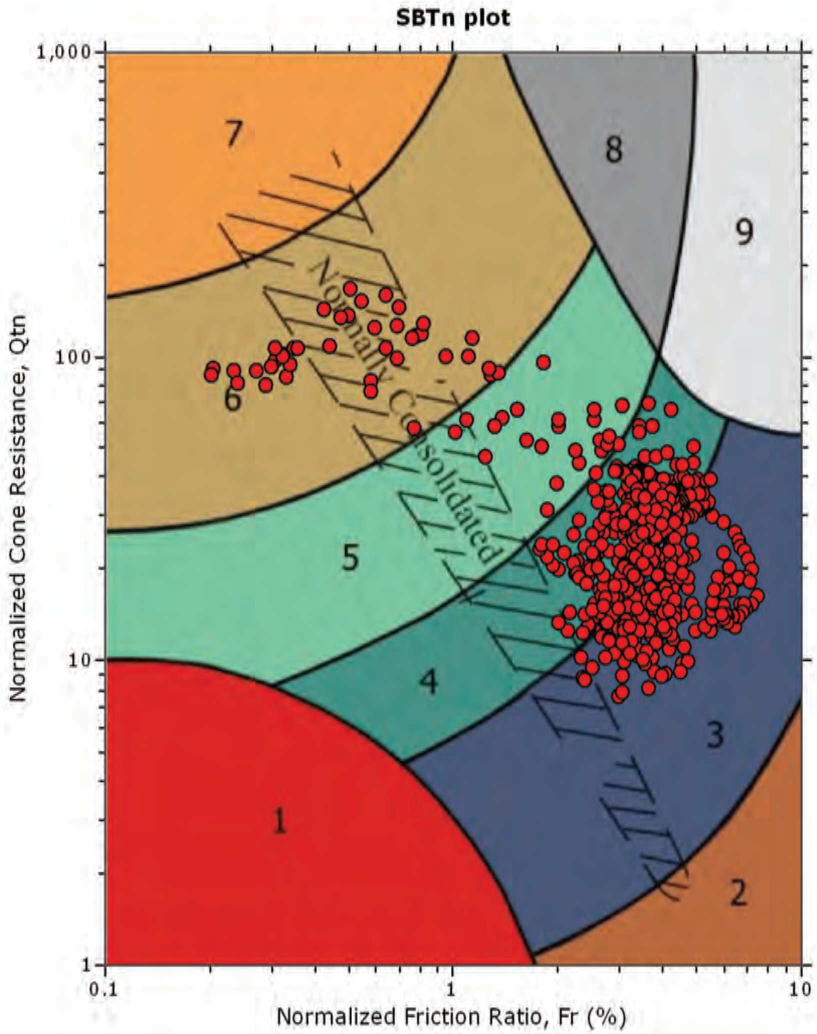
SBTn legend

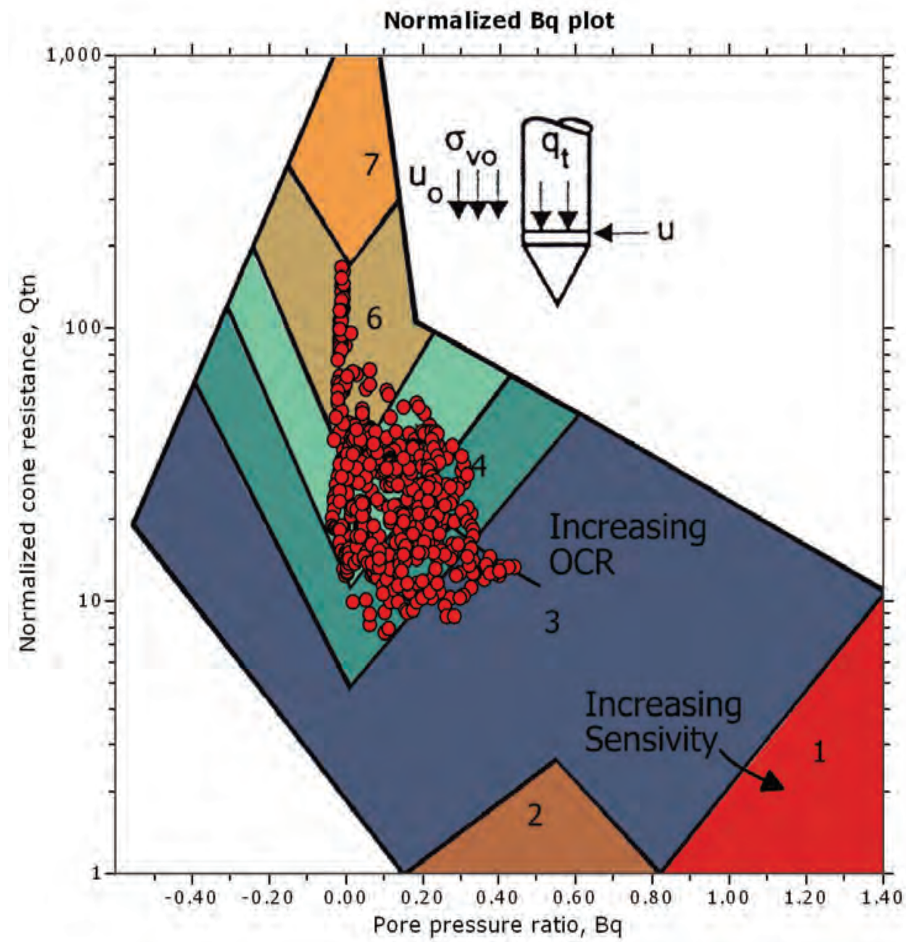
1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty clay
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to clayey sand
9. Very stiff fine grained



Permeability
HAND AUGER
Depth (ft)
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
100
105
110
1x10 -9
1x10 -6
1x10 -3
Ksbt (ft/s)

SBT - Bq plots (normalized)





SBTn legend

- 1. Sensitive fine grained
- 2. Organic material
- 3. Clay to silty clay
- 4. Clayey silt to silty clay
- 5. Silty sand to sandy silt
- 6. Clean sand to silty sand
- 7. Gravely sand to sand
- 8. Very stiff sand to clayey sand
- 9. Very stiff fine grained

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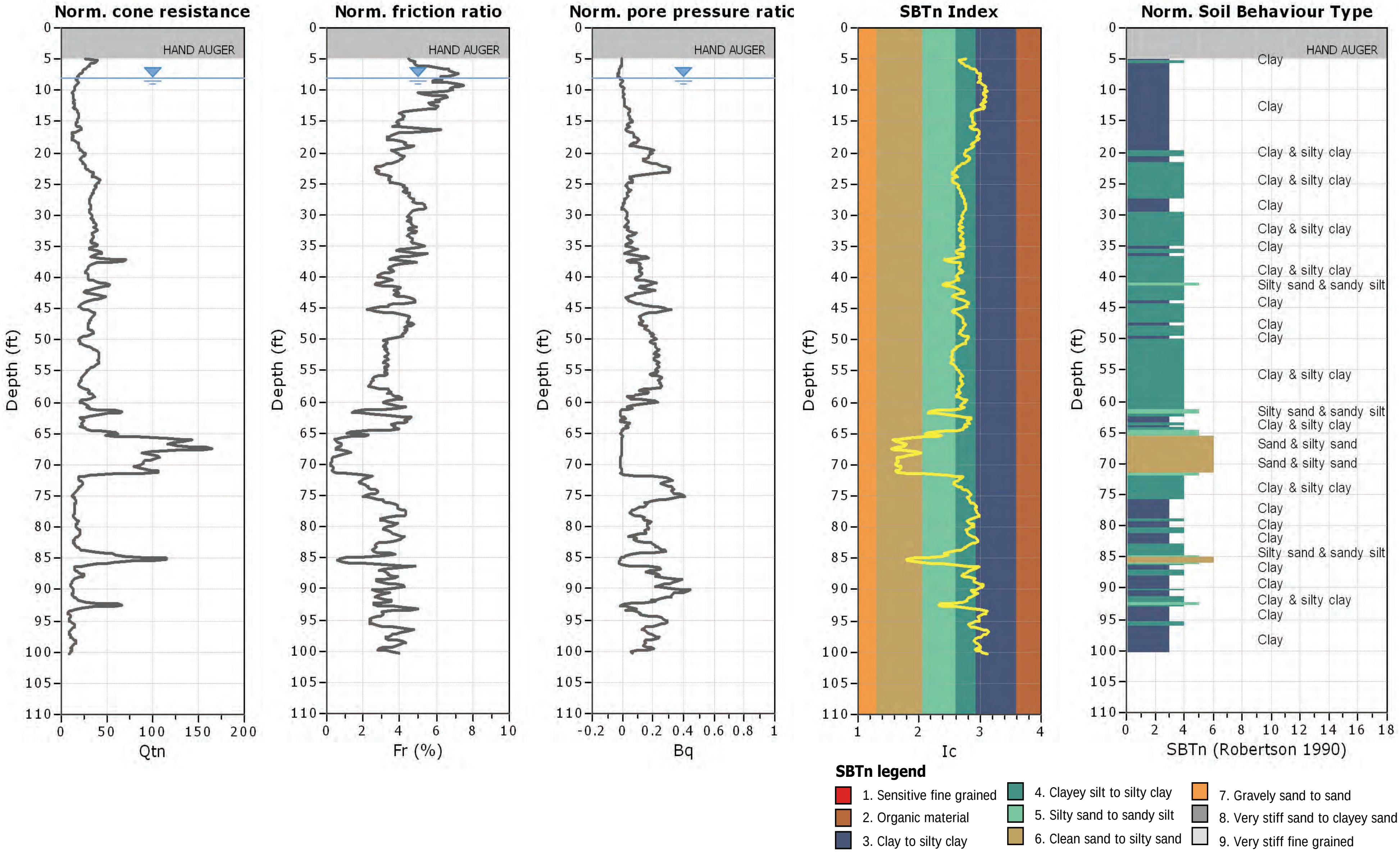
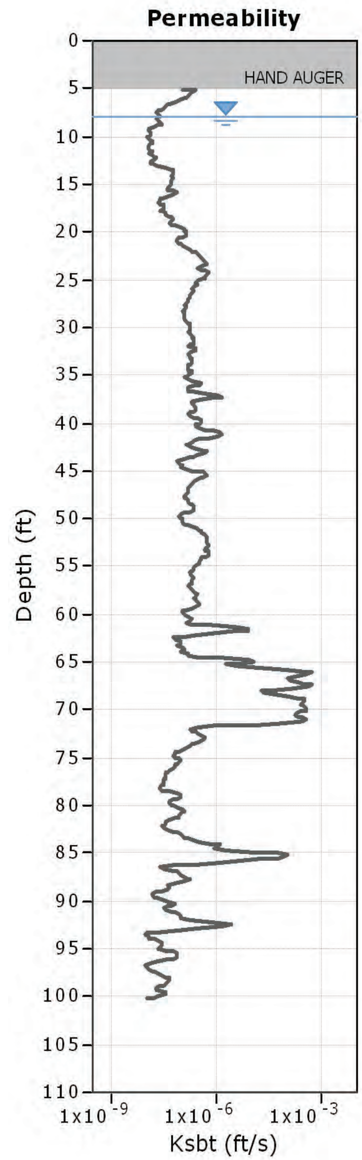
Geology and Groundwater Investigations Section

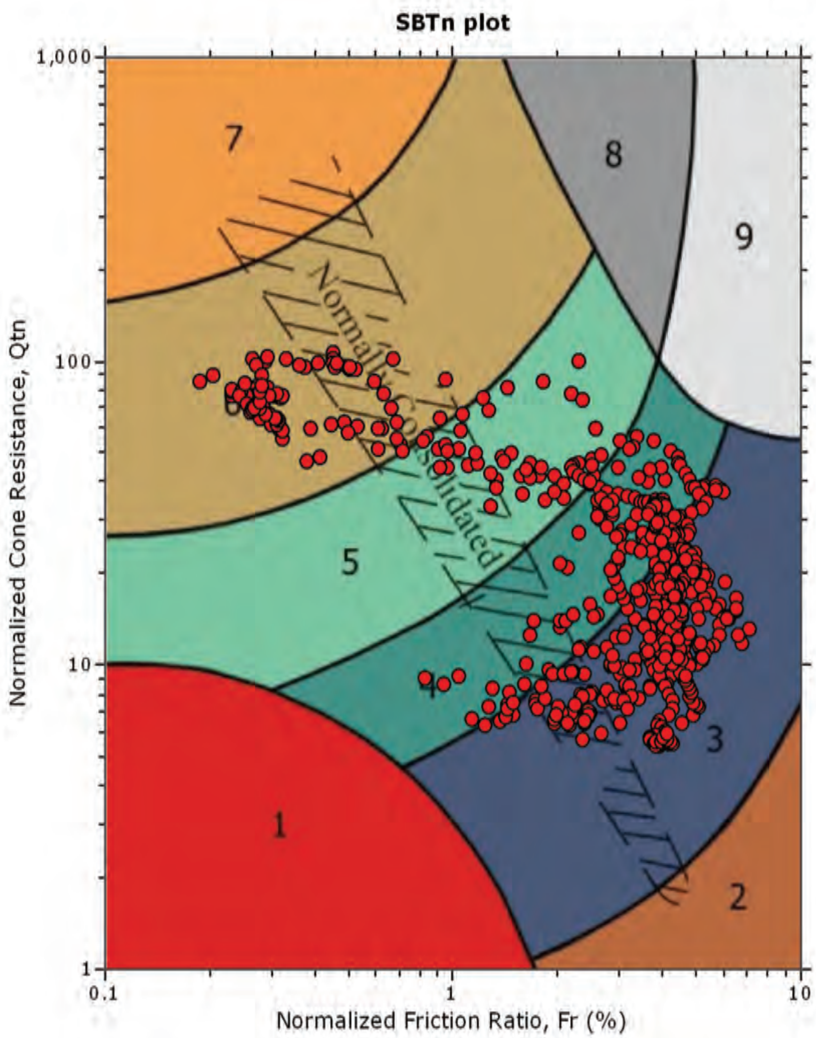
CPT: 141cpi4
Total depth: 100.23 ft, Date: 3/13/2012
Surface Elevation: 13.83 ft
Coords: X:0.00, Y:0.00
Cone Type: CPTu
Cone Operator: Gregg Drilling & Testing, Inc.

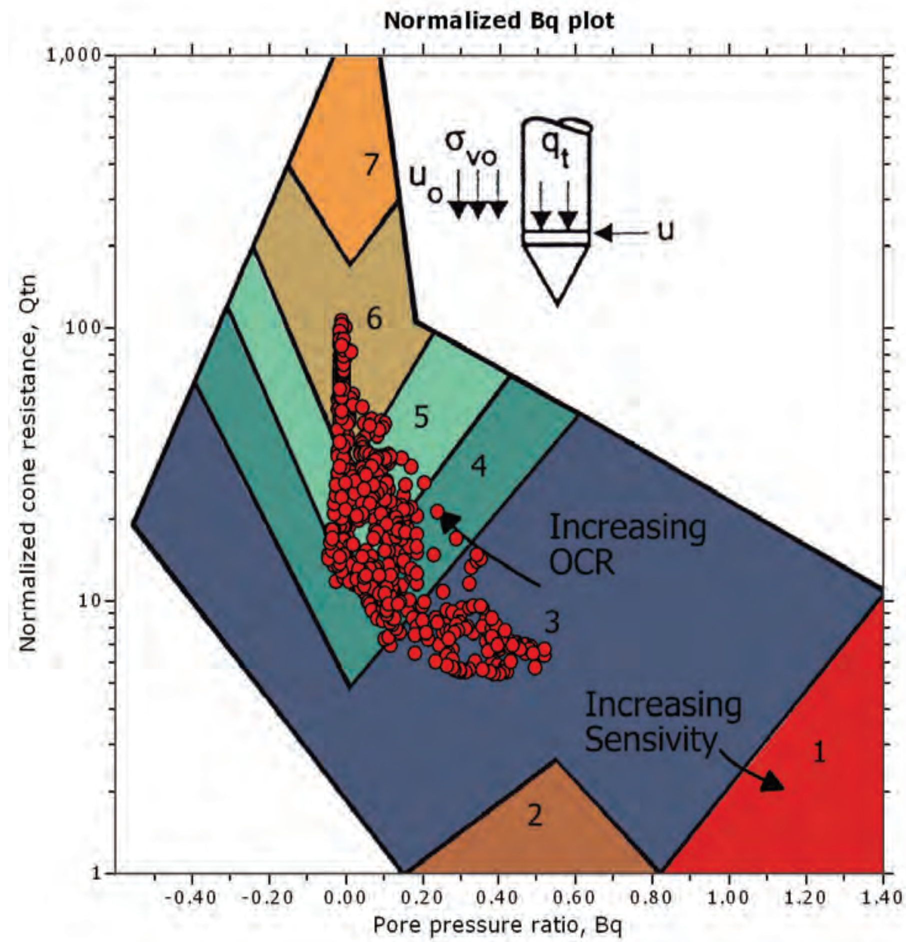
Project: Prospect Island Tidal Habitat Restoration Project
Location: Solano County




Permeability
HAND AUGER
Depth (ft)
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
100
105
110
1x10 -9
1x10 -6
1x10 -3
Ksbt (ft/s)

SBT - Bq plots (normalized)





SBTn legend

1. Sensitive fine grained	4. Clayey silt to silty clay	7. Gravely sand to sand
2. Organic material	5. Silty sand to sandy silt	8. Very stiff sand to clayey sand
3. Clay to silty clay	6. Clean sand to silty sand	9. Very stiff fine grained

California Department of Water Resources
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North Central Region Office
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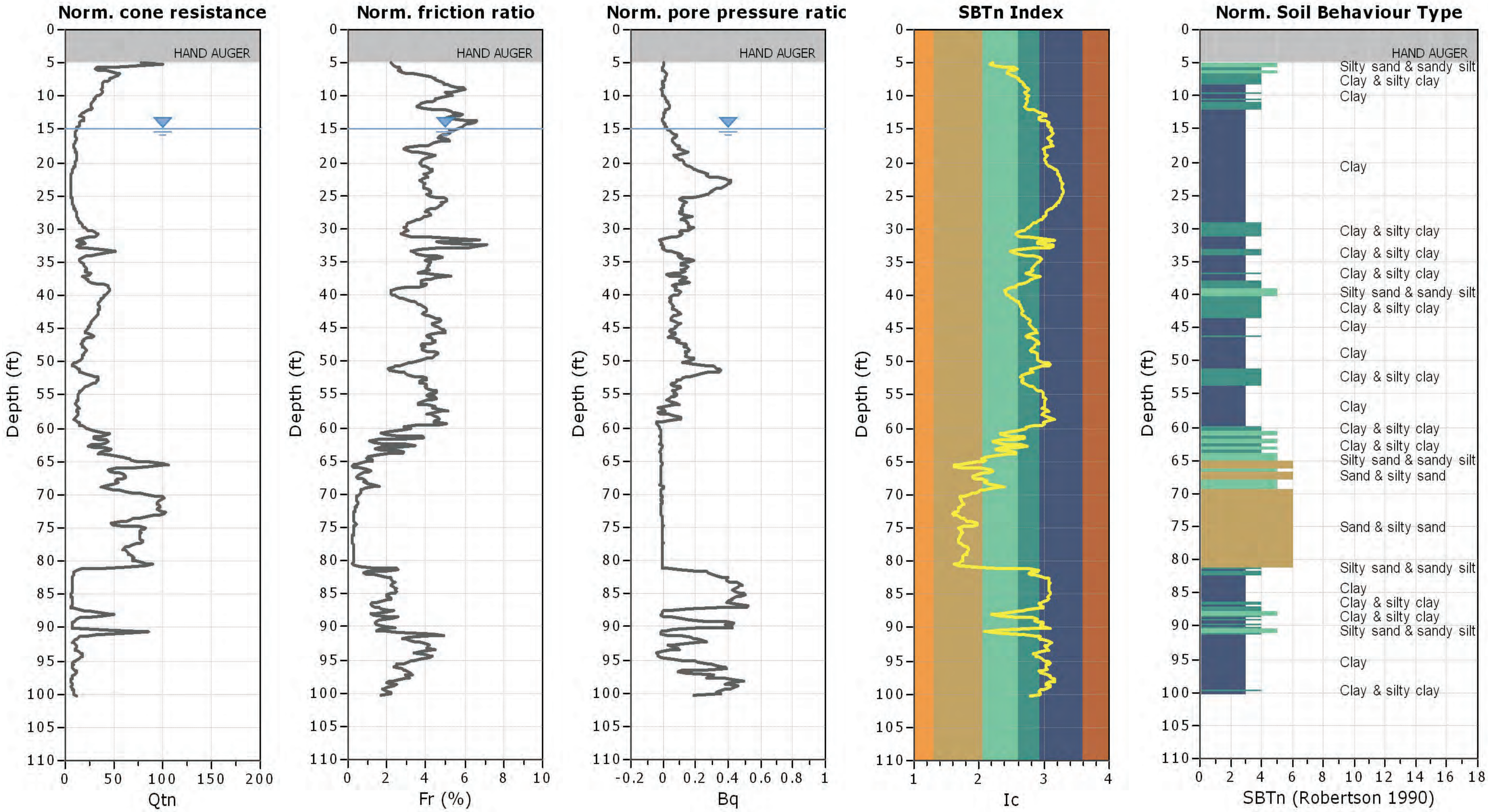
CPT: 141cpi5
Total depth: 100.23 ft, Date: 3/13/2012
Surface Elevation: 17.89 ft
Coords: X:0.00, Y:0.00
Cone Type: CPTu
Cone Operator: Gregg Drilling & Testing, Inc.

Project: Prospect Island Tidal Habitat Restoration Project
Location: Solano County

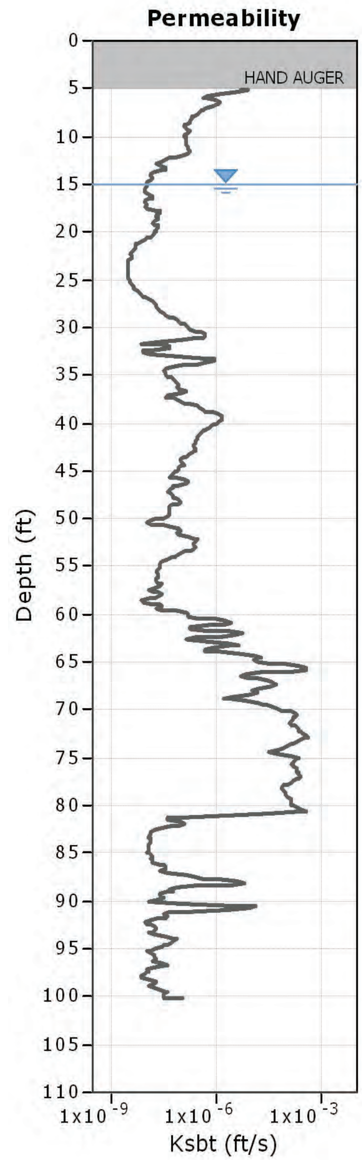


SBTn legend
1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty clay
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to clayey sand
9. Very stiff fine grained

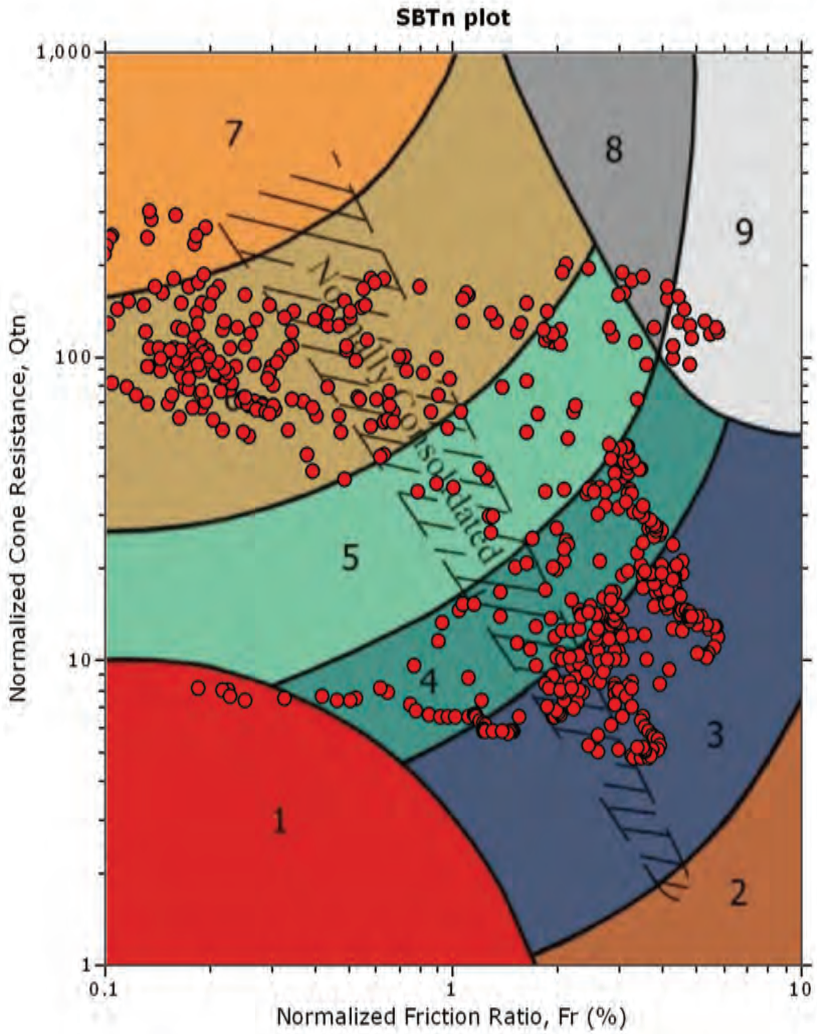
CPT: 141cpi5

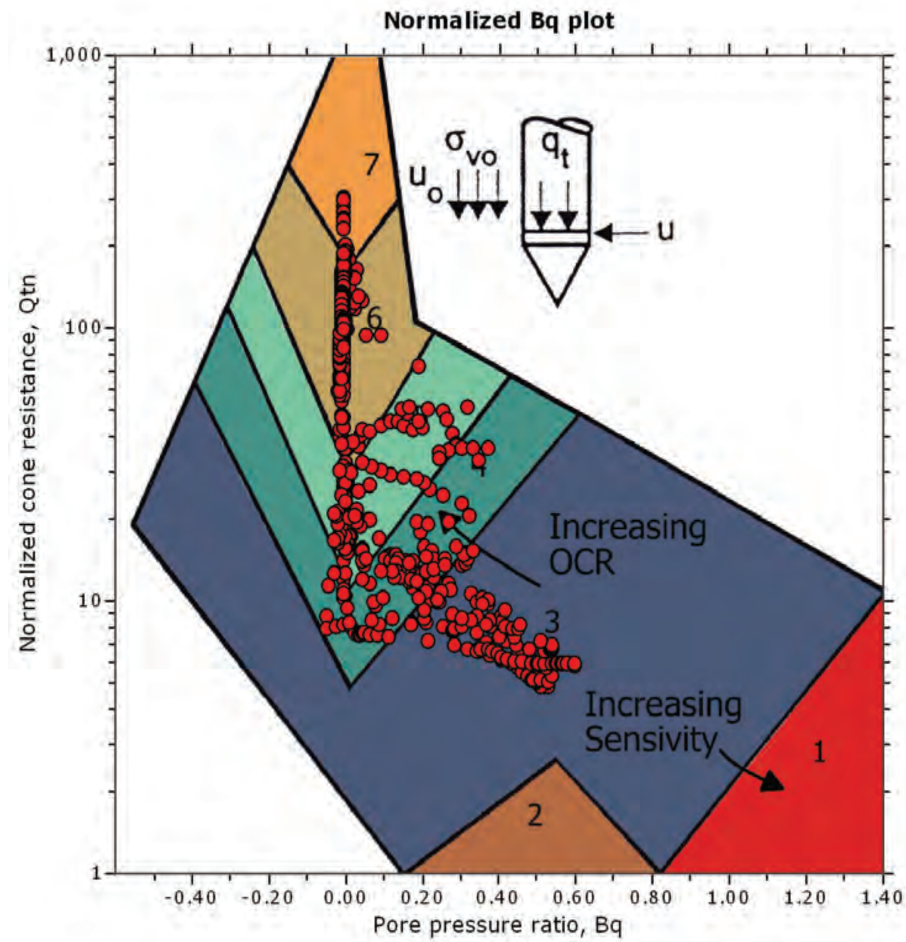
Total depth: 100.23 ft, Date: 3/13/2012
Surface Elevation: 17.89 ft
Coords: X:0.00, Y:0.00
Cone Type: CPTu
Cone Operator: Gregg Drilling & Testing, Inc.

Project: **Prospect Island Tidal Habitat Restoration Project**
Location: **Solano County**



SBT - Bq plots (normalized)





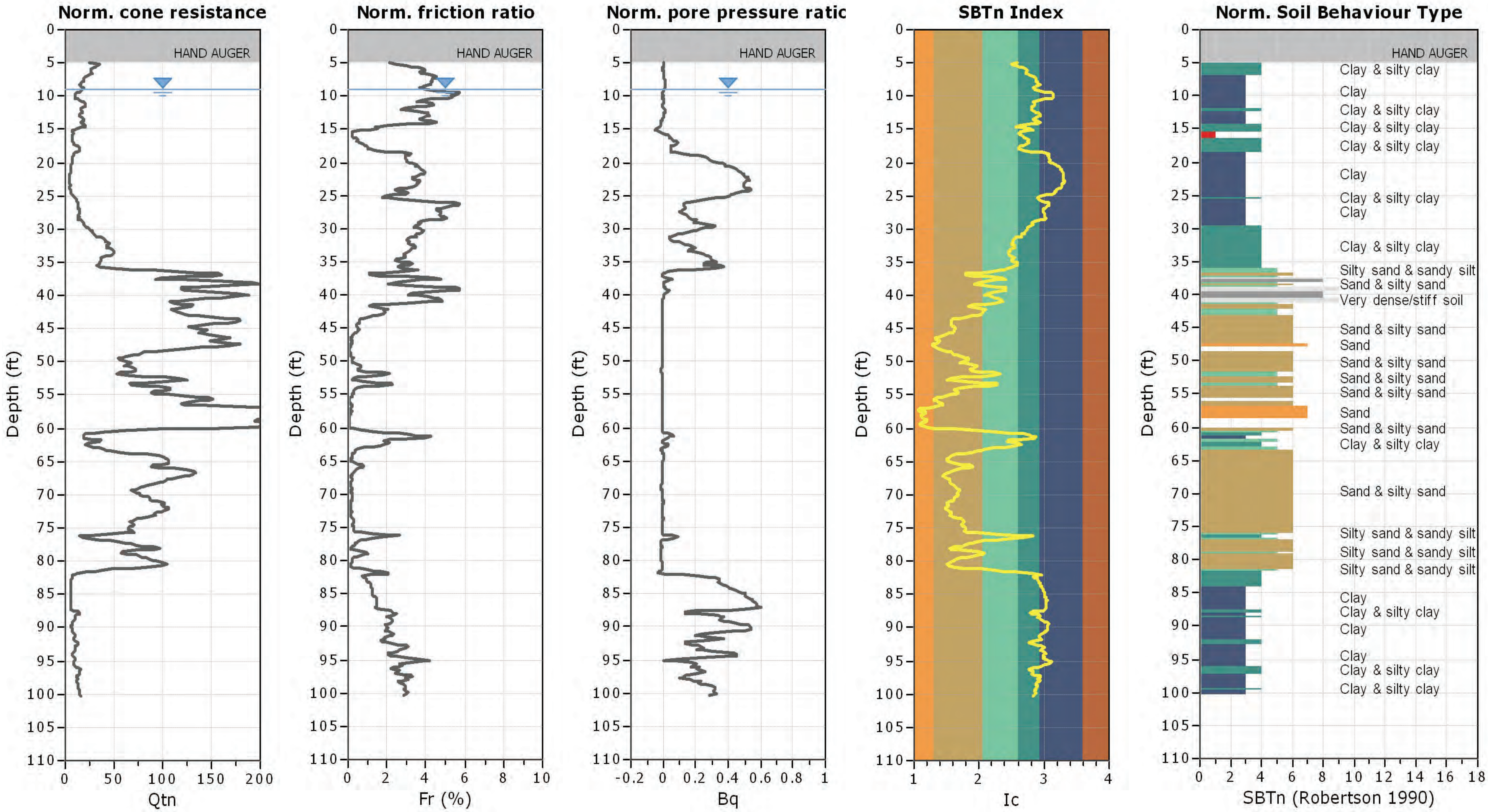
SBTn legend

- 1. Sensitive fine grained
- 2. Organic material
- 3. Clay to silty clay
- 4. Clayey silt to silty clay
- 5. Silty sand to sandy silt
- 6. Clean sand to silty sand
- 7. Gravely sand to sand
- 8. Very stiff sand to clayey sand
- 9. Very stiff fine grained

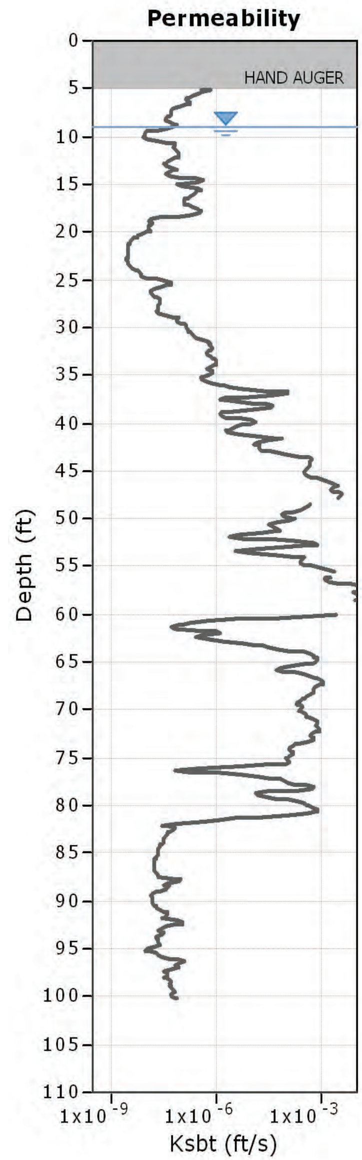
California Department of Water Resources
Division of Integrated Regional Water Management
North Central Region Office
Geology and Groundwater Investigations Section

CPT: 141cpi6
Total depth: 100.23 ft, Date: 3/13/2012
Surface Elevation: 16.55 ft
Coords: X:0.00, Y:0.00
Cone Type: CPTu
Cone Operator: Gregg Drilling & Testing, Inc.

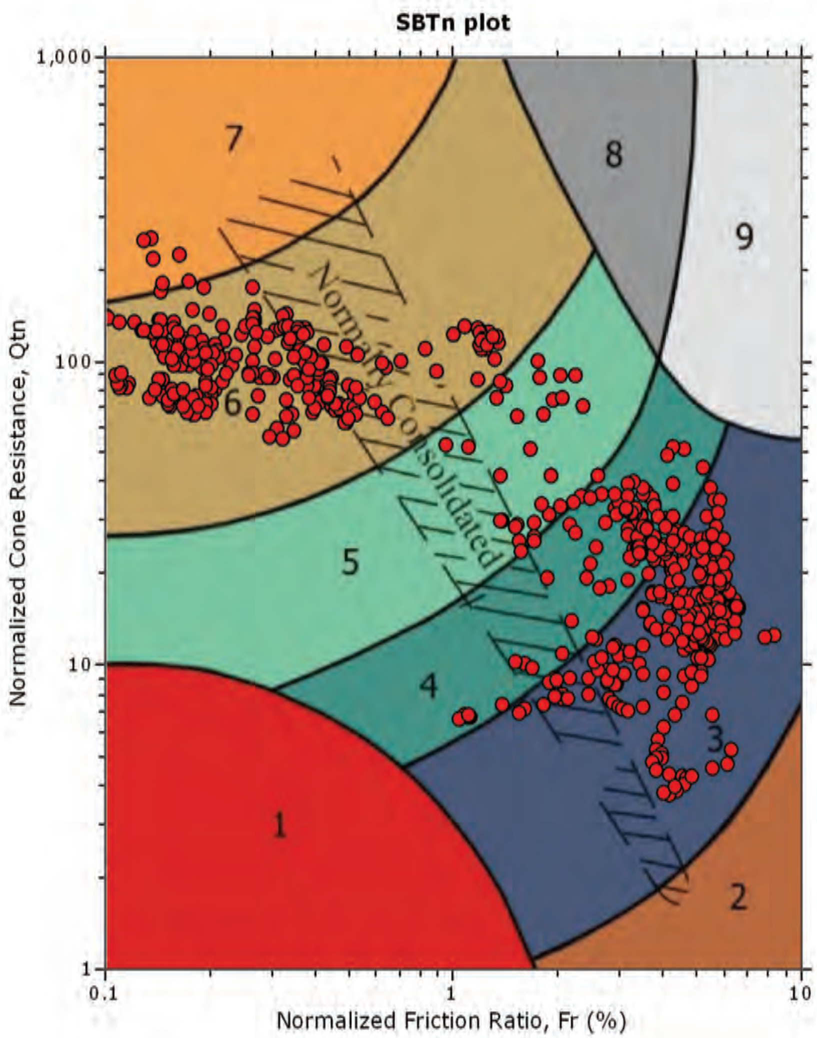
Project: **Prospect Island Tidal Habitat Restoration Project**
Location: **Solano County**

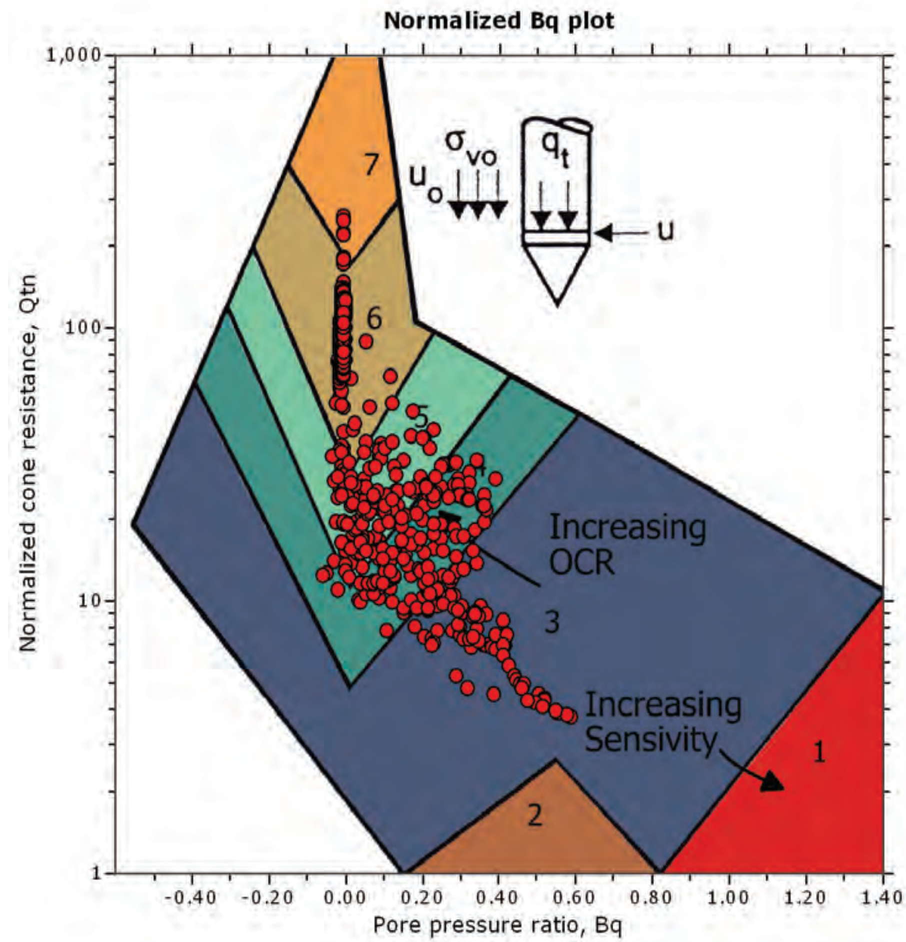


SBTn legend
1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty clay
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to clayey sand
9. Very stiff fine grained


Permeability
HAND AUGER
Depth (ft)
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
100
105
110
1x10 -9
1x10 -6
1x10 -3
Ksbt (ft/s)

SBT - Bq plots (normalized)





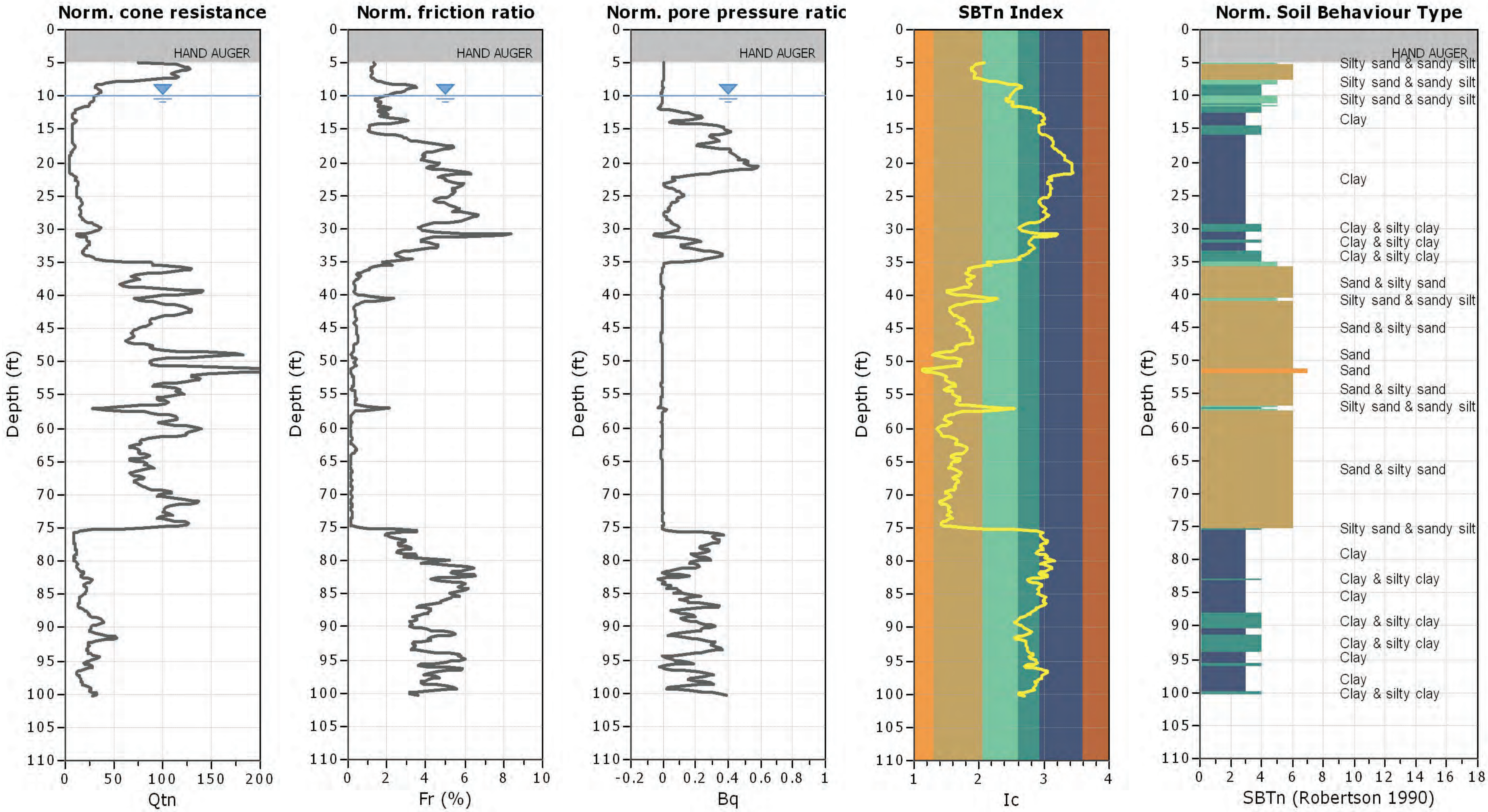
SBTn legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty clay
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to clayey sand
9. Very stiff fine grained

California Department of Water Resources
Division of Integrated Regional Water Management
North Central Region Office
Geology and Groundwater Investigations Section

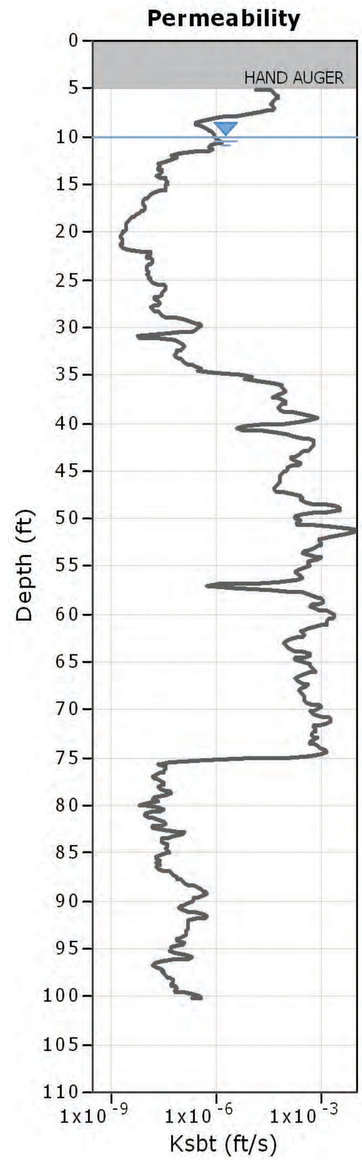
CPT: 141cpi7
Total depth: 100.23 ft, Date: 3/13/2012
Surface Elevation: 15.95 ft
Coords: X:0.00, Y:0.00
Cone Type: CPTu
Cone Operator: Gregg Drilling & Testing, Inc.

Project: **Prospect Island Tidal Habitat Restoration Project**
Location: **Solano County**



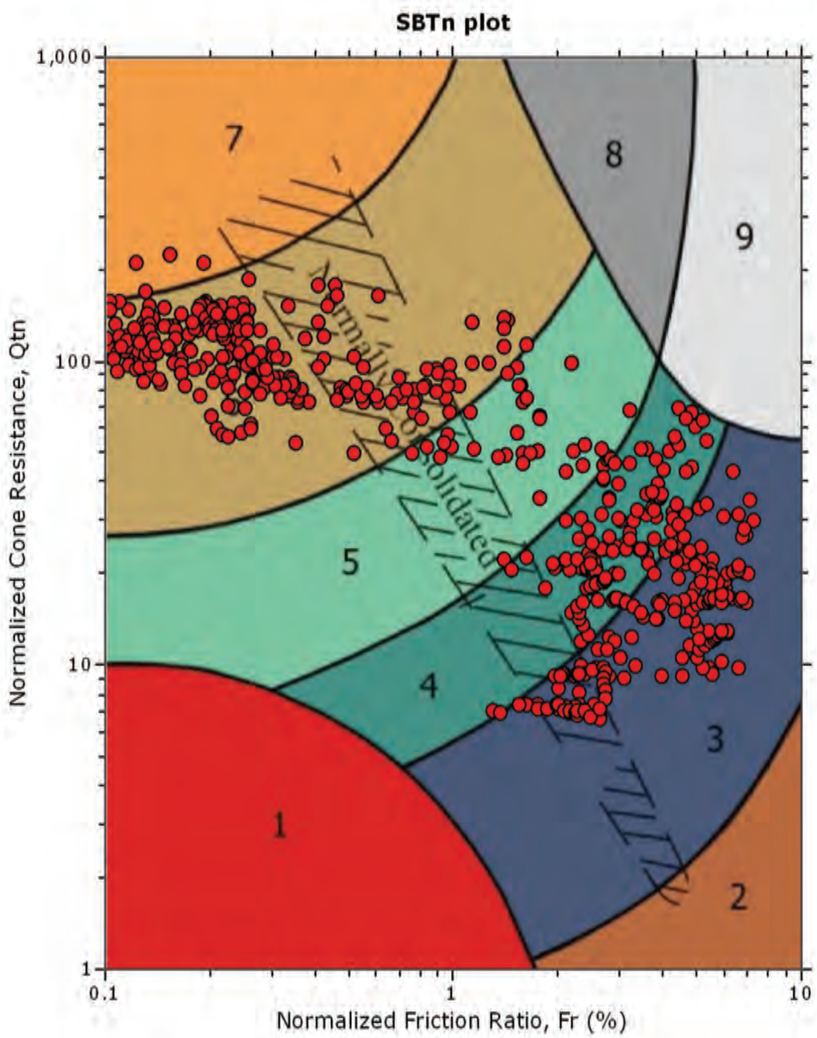
SBTn legend

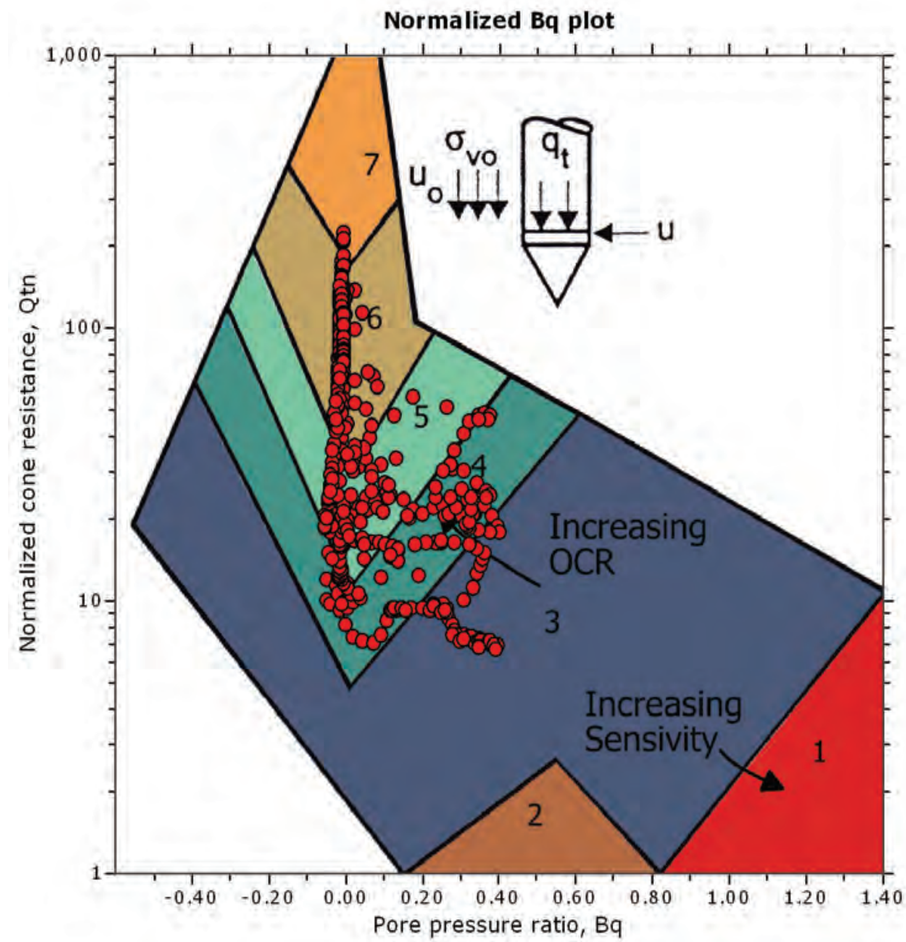
1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty clay
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to clayey sand
9. Very stiff fine grained



Permeability
HAND AUGER
Depth (ft)
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
100
105
110
1x10 -9
1x10 -6
1x10 -3
Ksbt (ft/s)

SBT - Bq plots (normalized)





SBTn legend

- 1. Sensitive fine grained
- 2. Organic material
- 3. Clay to silty clay
- 4. Clayey silt to silty clay
- 5. Silty sand to sandy silt
- 6. Clean sand to silty sand
- 7. Gravely sand to sand
- 8. Very stiff sand to clayey sand
- 9. Very stiff fine grained

California Department of Water Resources
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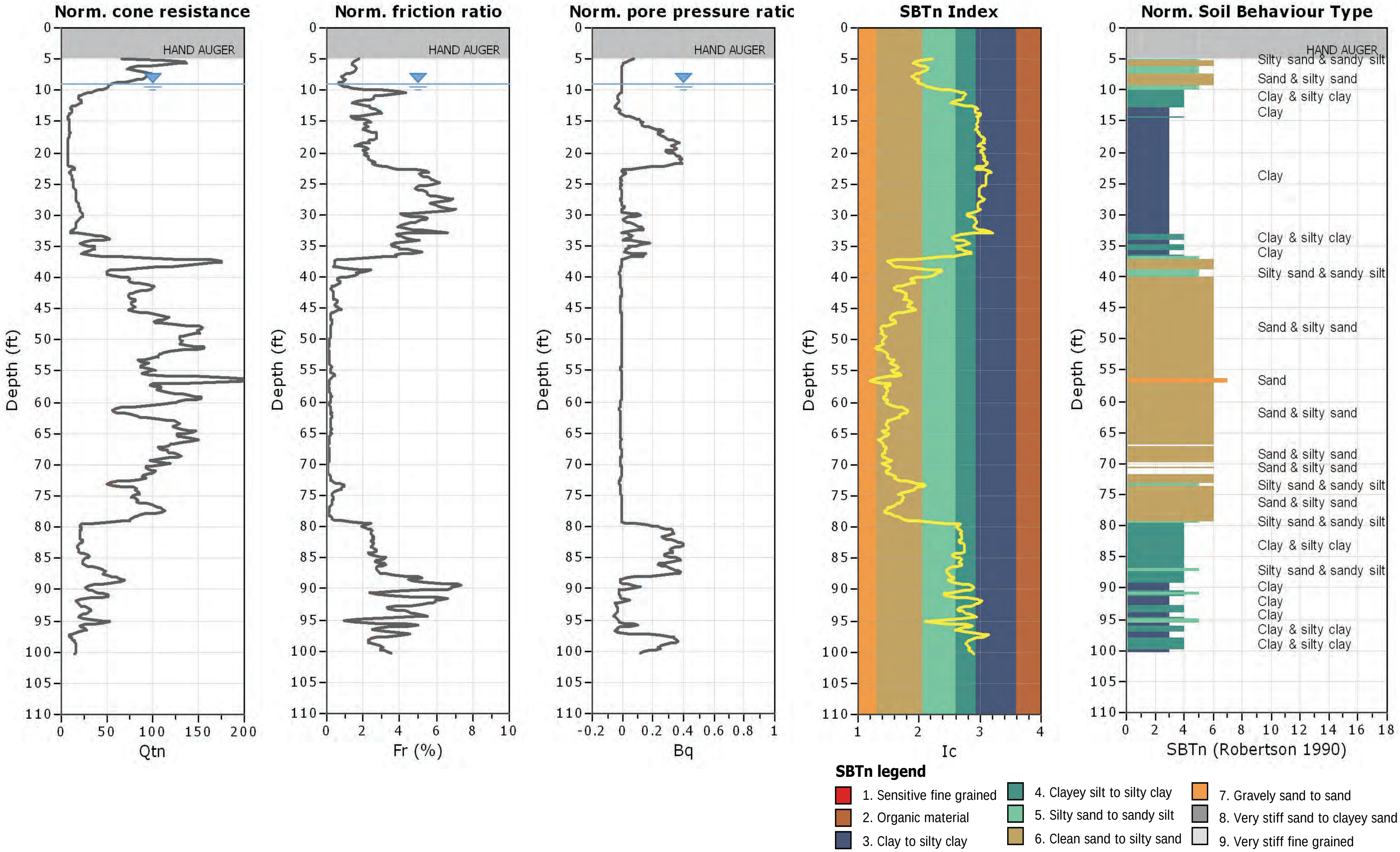
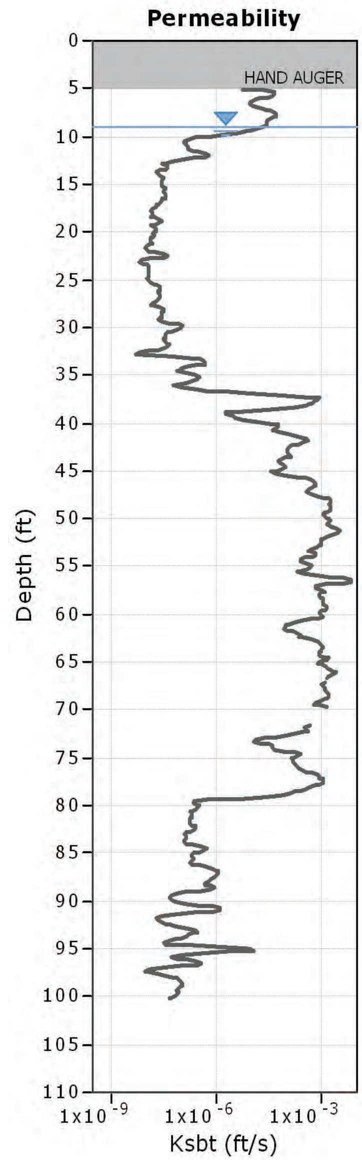
North Central Region Office
Geology and Groundwater Investigations Section

Project: Prospect Island Tidal Habitat Restoration Project
Location: Solano County

CPT: 141cpi8
Total depth: 100.23 ft, Date: 3/13/2012
Surface Elevation: 15.80 ft
Coords: X:0.00, Y:0.00
Cone Type: CPTu
Cone Operator: Gregg Drilling & Testing, Inc.





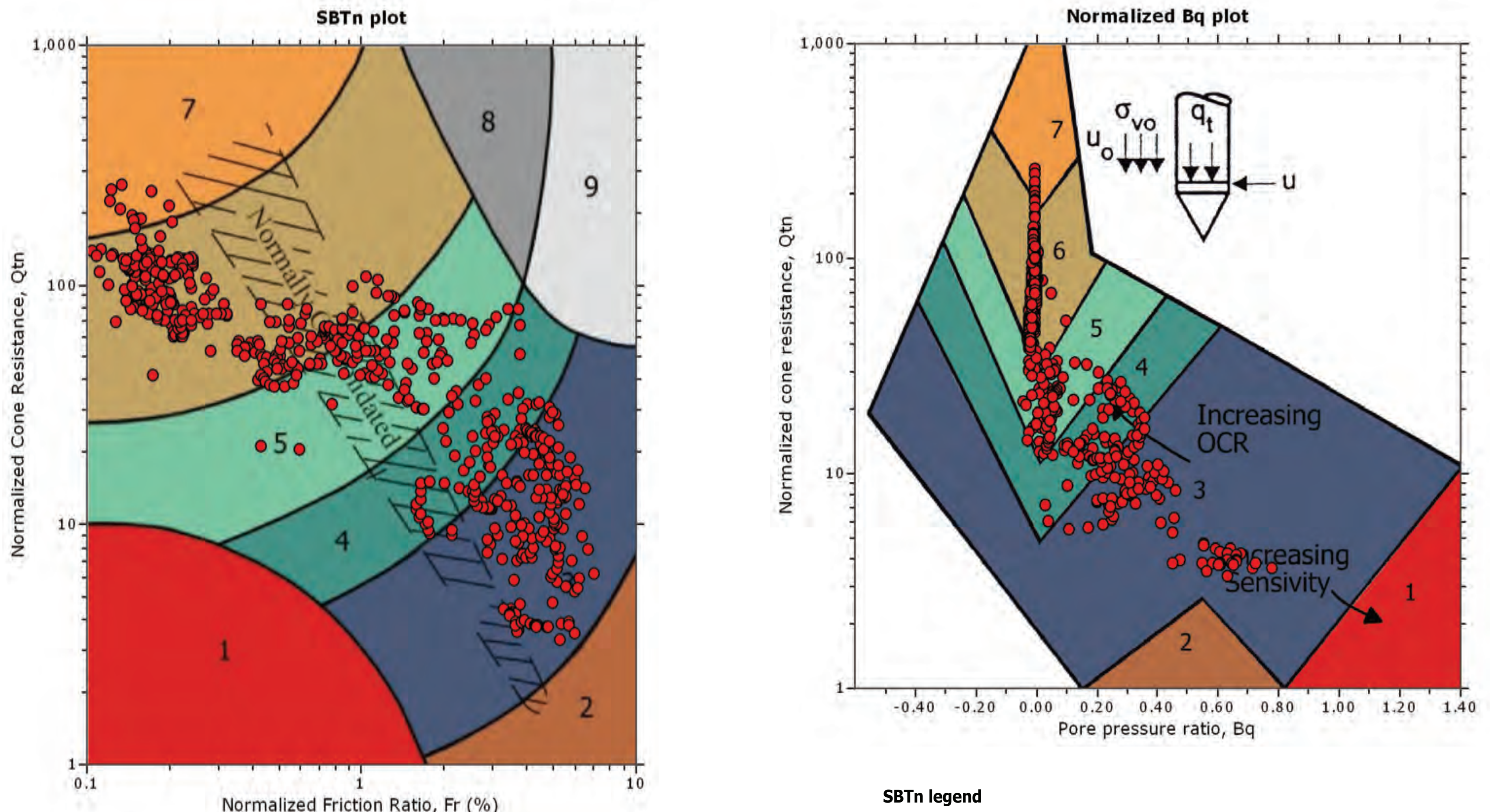
Permeability
HAND AUGER
Depth (ft)
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
100
105
110
1x10 -9
1x10 -6
1x10 -3
Ksbt (ft/s)

California Department of Water Resources
Division of Integrated Regional Water Management
North Central Region Office
Geology and Groundwater Investigations Section

Project: **Prospect Island Tidal Habitat Restoration Project**
Location: **Solano County**

CPT: 141cpi9
Total depth: 100.23 ft, Date: 3/13/2012
Surface Elevation: 15.62 ft
Coords: X:0.00, Y:0.00
Cone Type: CPTu
Cone Operator: Gregg Drilling & Testing, Inc.

SBT - Bq plots (normalized)



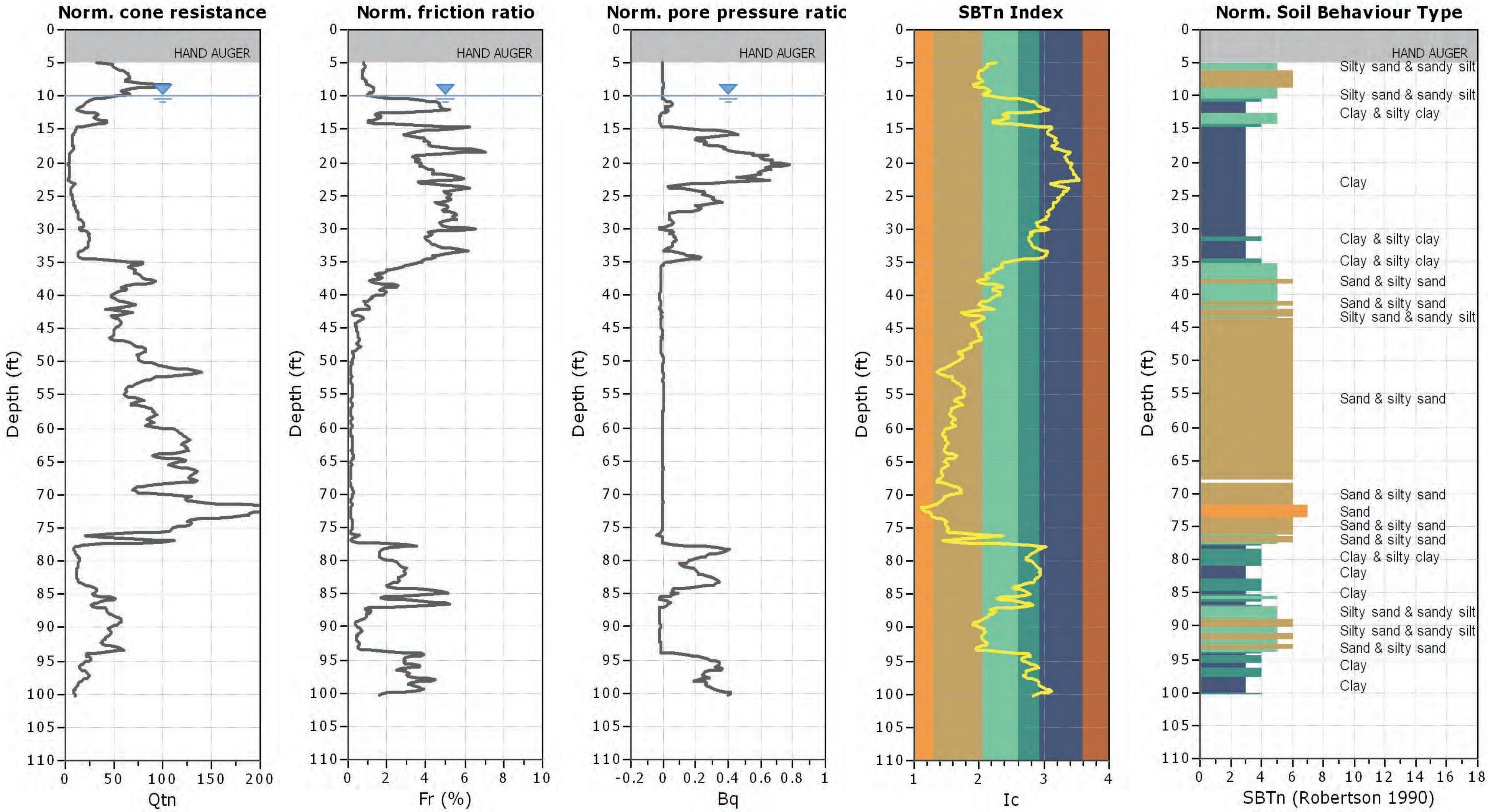
SBTn legend

- 1. Sensitive fine grained
- 2. Organic material
- 3. Clay to silty clay
- 4. Clayey silt to silty clay
- 5. Silty sand to sandy silt
- 6. Clean sand to silty sand
- 7. Gravely sand to sand
- 8. Very stiff sand to clayey sand
- 9. Very stiff fine grained

CPT: 141cpi9

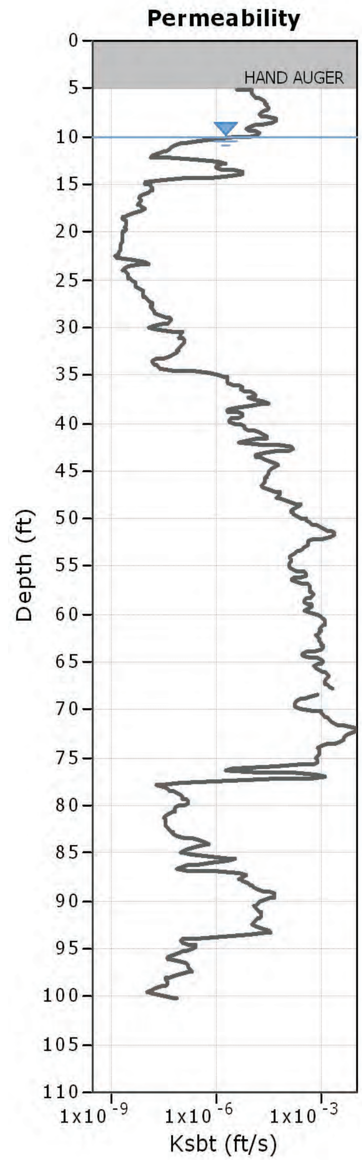
Total depth: 100.23 ft, Date: 3/13/2012
Surface Elevation: 15.62 ft
Coords: X:0.00, Y:0.00
Cone Type: CPTu
Cone Operator: Gregg Drilling & Testing, Inc.

Project: Prospect Island Tidal Habitat Restoration Project
Location: Solano County



SBTn legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty clay
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to clayey sand
9. Very stiff fine grained


Permeability
HAND AUGER
Depth (ft)
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
100
105
110
1x10 -9
1x10 -6
1x10 -3
Ksbt (ft/s)

Dissipation Tests Results

Dissipation tests

Dissipation tests consists of stopping the piezocone penetration and observing porepressures (u) with elapsed time (t). The data are automatic recorded by the field computer and should take place until a minimum of 50% dissipation.

The porepressures are plotted as a function of square root of (t). The graphical technique suggested by Robertson and Campanella (1989), yields a value for t_{50}, which corresponds to the time for 50% consolidation.

The value of the coefficient of consolidation in the radial or horizontal direction c_h was then calculated by Houlsby and Teh's (1988) theory using the following equation:

$$c_h = \frac{T \times r^2 \times I_r^{0.5}}{t_{50}}$$

where:

T: time factor given by Houlsby and Teh's (1988) theory corresponding to the porepressure position
r: piezocone radius
I_r: stiffness index, equal to shear modulus G divided by the undrained strength of clay (S_u).
t_{50}: time corresponding to 50% consolidation

Permeability estimates based on dissipation test

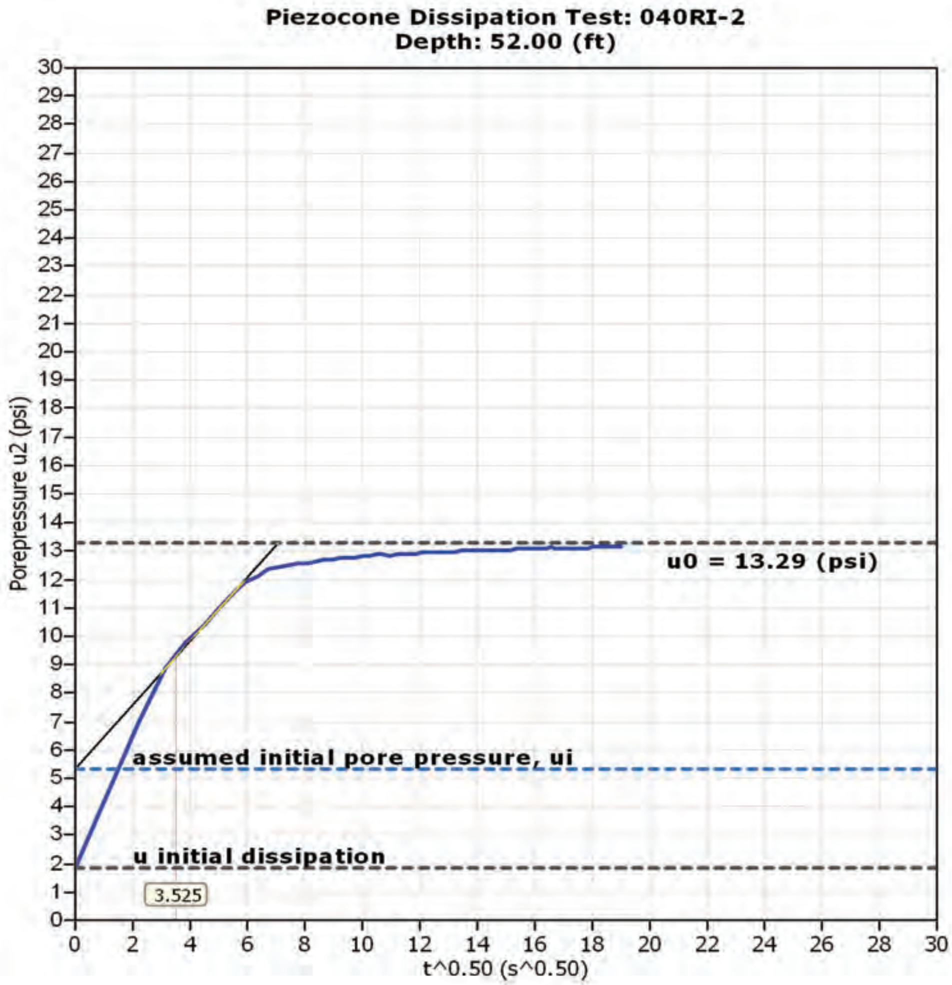
The dissipation of pore pressures during a CPTu dissipation test is controlled by the coefficient of consolidation in the horizontal direction (c_h) which is influenced by a combination of the soil permeability (k_h) and compressibility (M), as defined by the following:

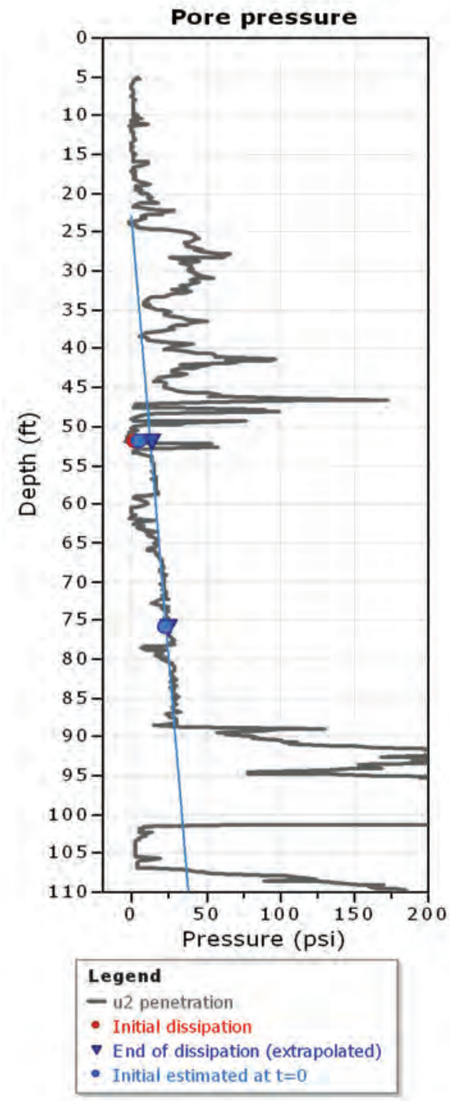
$$k_h = c_h \times \gamma_w / M$$

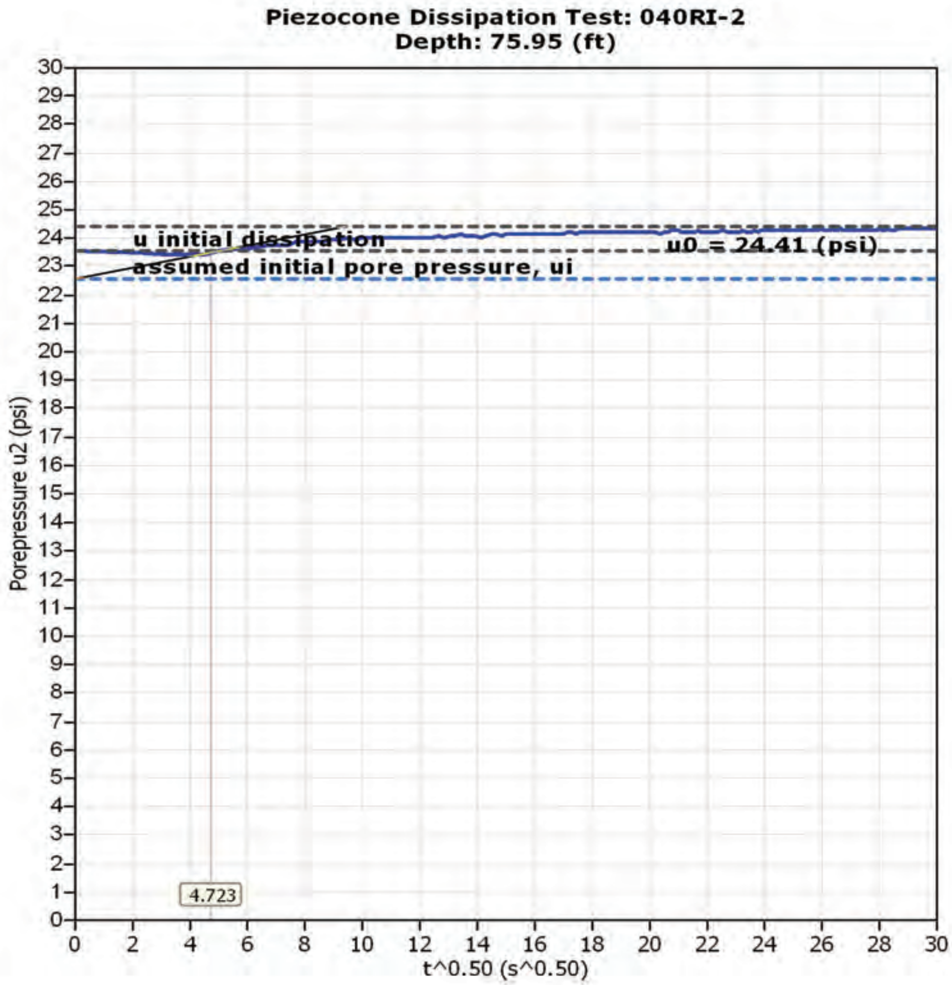
where: M is the 1-D constrained modulus and γ_w is the unit weight of water, in compatible units.

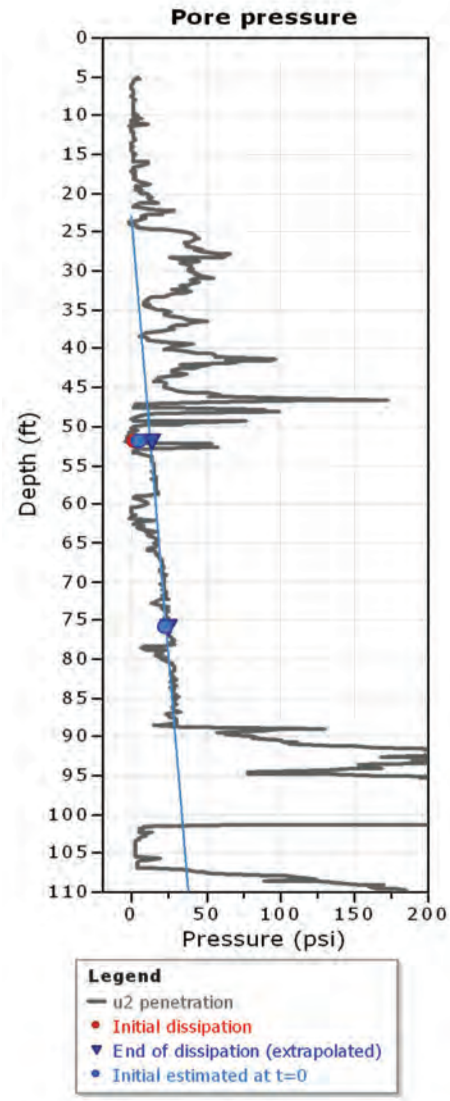
Tabular results

CPTU Borehole	Depth (ft)	$(t_{50})^{0.50}$	t_{50} (s)	t_{50} (years)	G/S_u	c_h (ft^2/s)	c_h ($ft^2/year$)	M (tsf)	k_h (ft/s)
040RI-2	52.00	3.5	12	3.94E-007	500.00	2.29E-003	72061	1000.00	7.13E-008
040RI-2	75.95	4.7	22	7.07E-007	500.00	1.27E-003	40154	1000.00	3.98E-008


Piezocone Dissipation Test: 040RI-2
Depth: 52.00 (ft)
Porepressure u2 (psi)
t^0.50 (s^0.50)
u0 = 13.29 (psi)
assumed initial pore pressure, ui
u initial dissipation
3.525


Pore pressure
Depth (ft)
Pressure (psi)
Legend
u2 penetration
Initial dissipation
End of dissipation (extrapolated)
Initial estimated at t=0


Piezocone Dissipation Test: 040RI-2
Depth: 75.95 (ft)
u initial dissipation
assumed initial pore pressure, ui
u0 = 24.41 (psi)
4.723
Porepressure u2 (psi)
t^0.50 (s^0.50)


Pore pressure
Depth (ft)
Pressure (psi)
Legend
u2 penetration
Initial dissipation
End of dissipation (extrapolated)
Initial estimated at t=0

Dissipation Tests Results

Dissipation tests

Dissipation tests consists of stopping the piezocone penetration and observing porepressures (u) with elapsed time (t). The data are automatic recorded by the field computer and should take place until a minimum of 50% dissipation.

The porepressures are plotted as a function of square root of (t). The graphical technique suggested by Robertson and Campanella (1989), yields a value for t_{50}, which corresponds to the time for 50% consolidation.

The value of the coefficient of consolidation in the radial or horizontal direction c_h was then calculated by Houlsby and Teh's (1988) theory using the following equation:

$$c_h = \frac{T \times r^2 \times I_r^{0.5}}{t_{50}}$$

where:

T: time factor given by Houlsby and Teh's (1988) theory corresponding to the porepressure position
r: piezocone radius
I_r: stiffness index, equal to shear modulus G divided by the undrained strength of clay (S_u).
t_{50}: time corresponding to 50% consolidation

Permeability estimates based on dissipation test

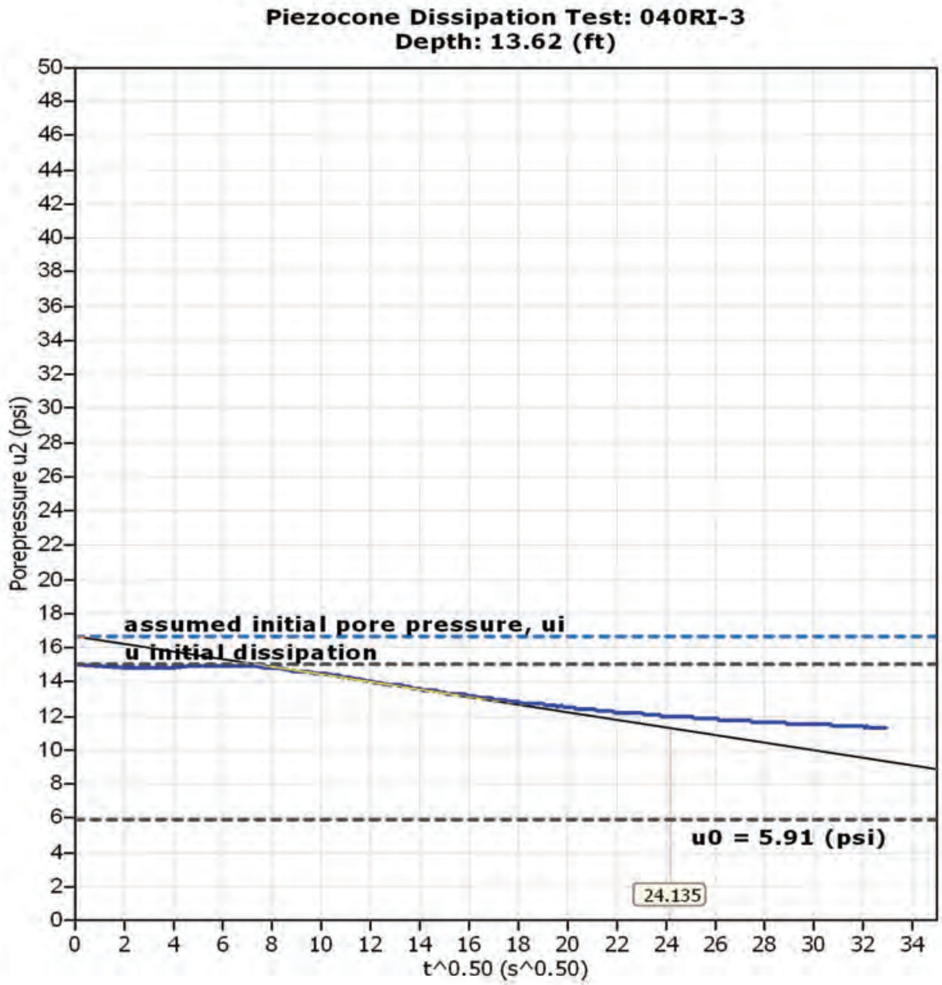
The dissipation of pore pressures during a CPTu dissipation test is controlled by the coefficient of consolidation in the horizontal direction (c_h) which is influenced by a combination of the soil permeability (k_h) and compressibility (M), as defined by the following:

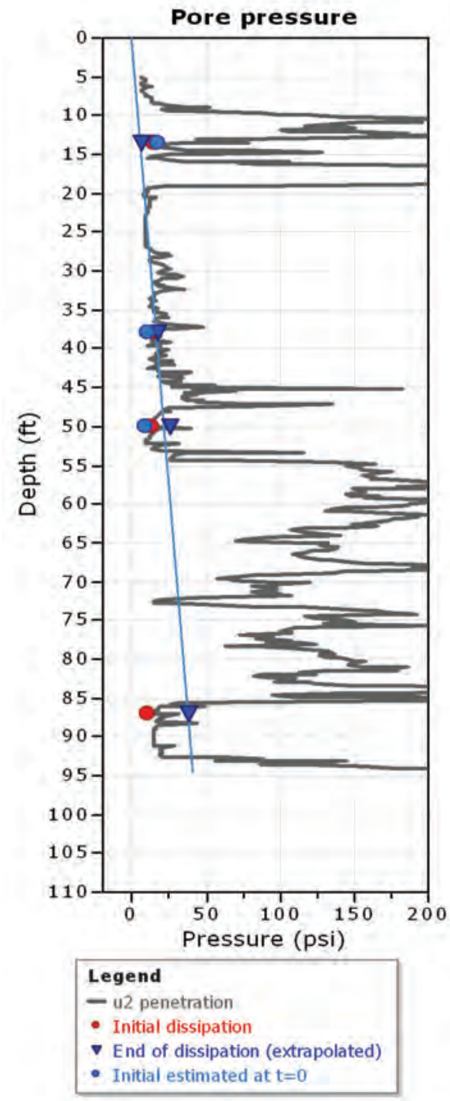
$$k_h = c_h \times \gamma_w / M$$

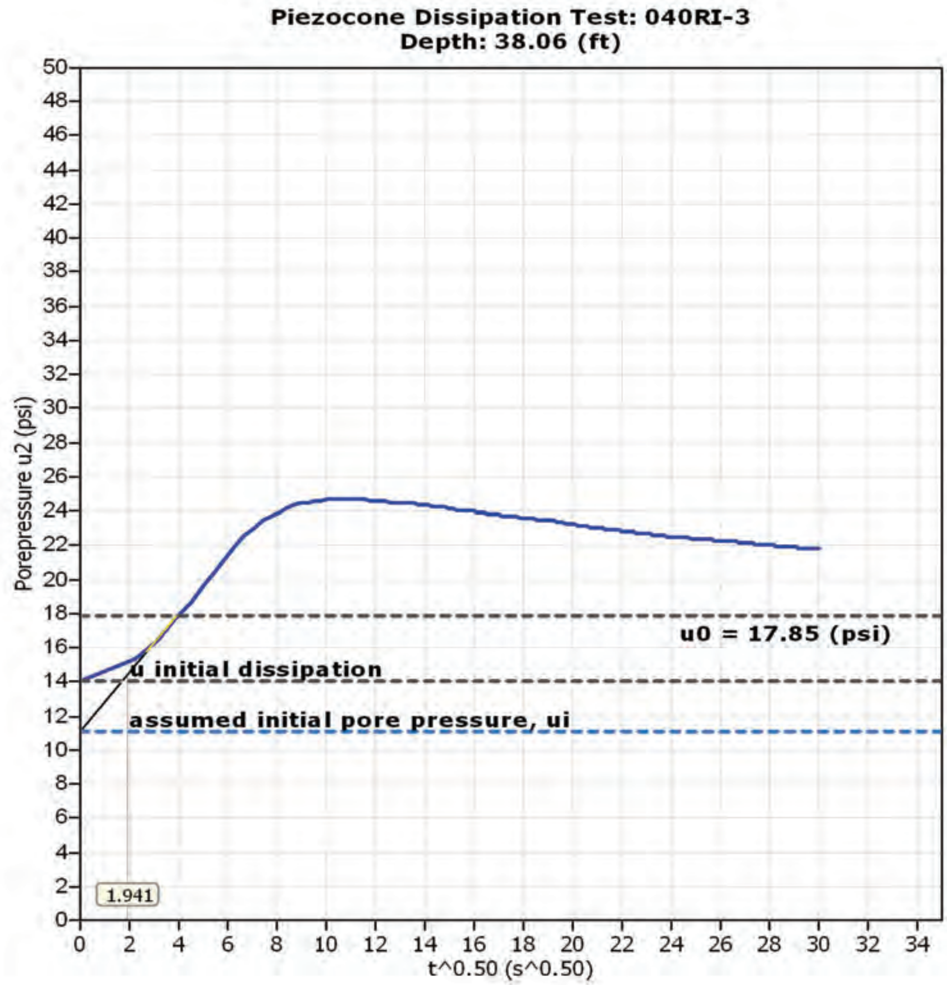
where: M is the 1-D constrained modulus and γ_w is the unit weight of water, in compatible units.

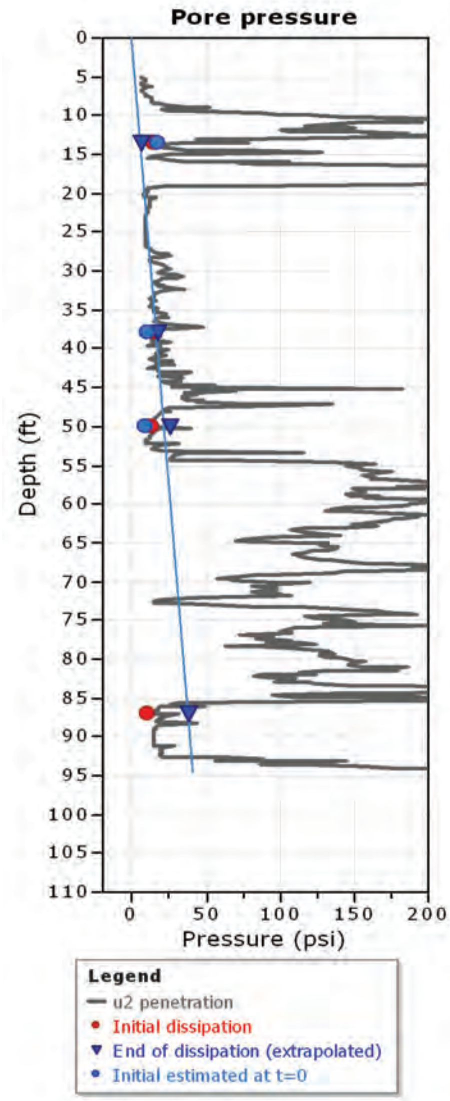
Tabular results

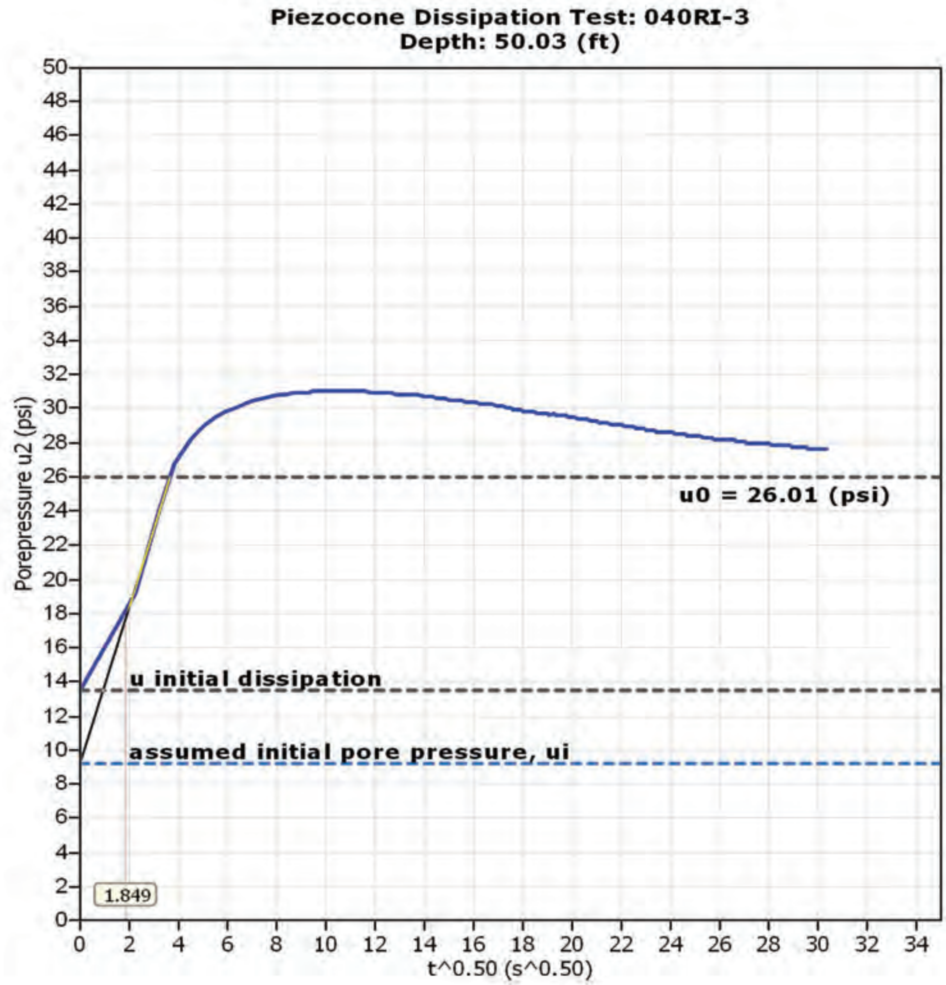
CPTU Borehole	Depth (ft)	$(t_{50})^{0.50}$	t_{50} (s)	t_{50} (years)	G/S_u	c_h (ft^2/s)	c_h ($ft^2/year$)	M (tsf)	k_h (ft/s)
040RI-3	13.62	24.1	583	1.85E-005	500.00	4.88E-005	1538	1000.00	1.52E-009
040RI-3	38.06	1.9	4	1.19E-007	500.00	7.54E-003	237791	1000.00	2.35E-007
040RI-3	50.03	1.8	3	1.08E-007	500.00	8.31E-003	262108	1000.00	2.59E-007
040RI-3	87.11	1.8	3	1.08E-007	500.00	8.31E-003	262124	1000.00	2.59E-007

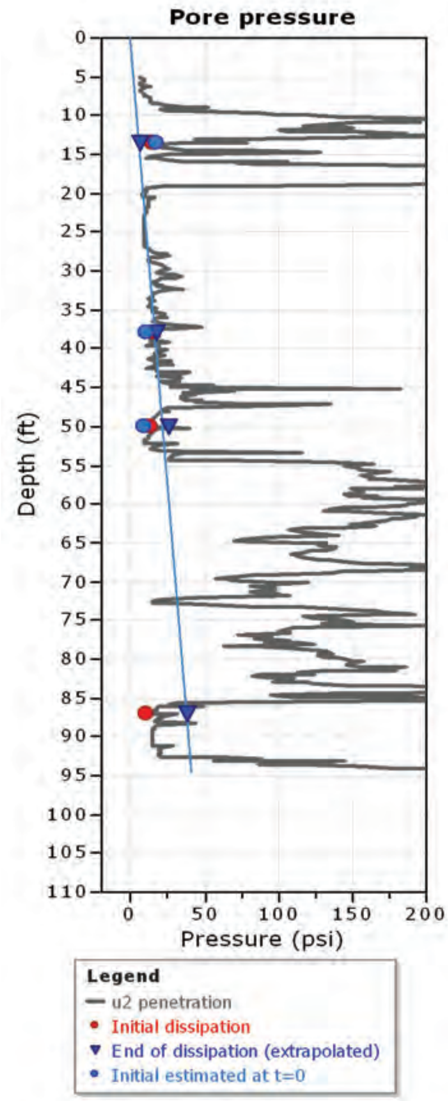

Piezocone Dissipation Test: 040RI-3
Depth: 13.62 (ft)
Porepressure u2 (psi)
t^0.50 (s^0.50)
assumed initial pore pressure, ui
u initial dissipation
u0 = 5.91 (psi)
24.135

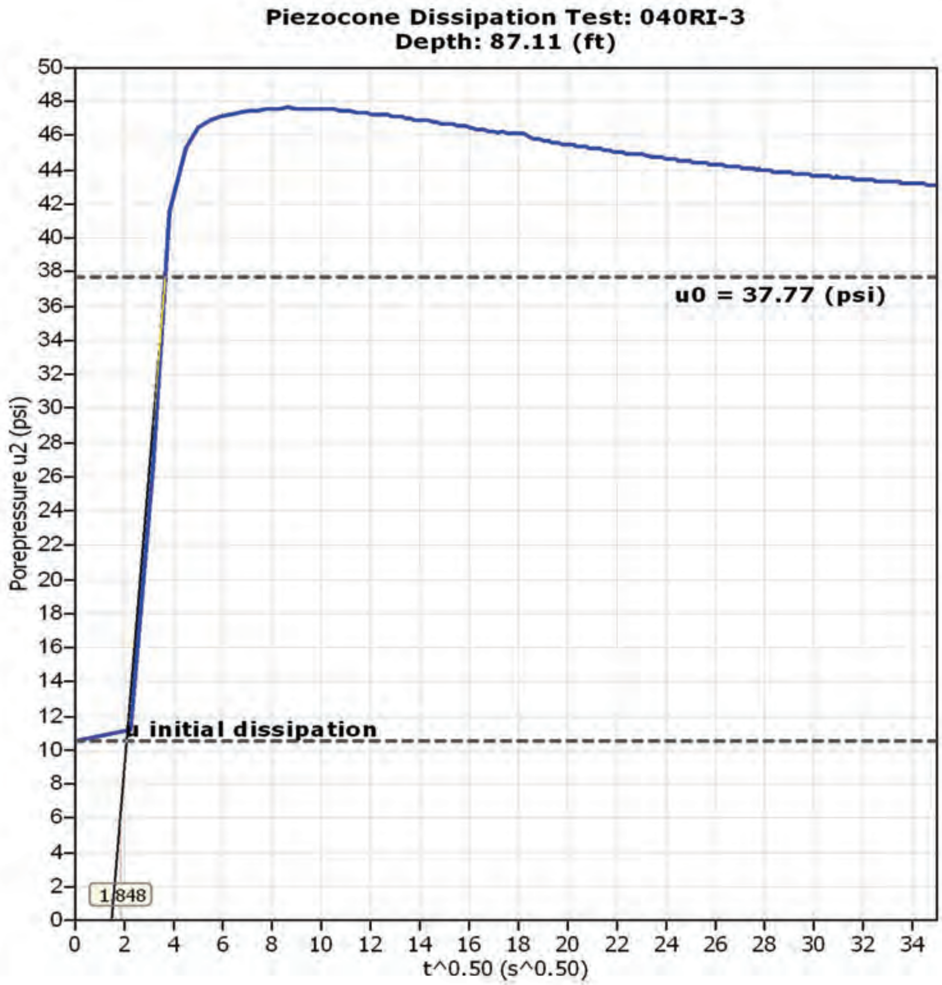

Pore pressure
Depth (ft)
Pressure (psi)
Legend
u2 penetration
Initial dissipation
End of dissipation (extrapolated)
Initial estimated at t=0

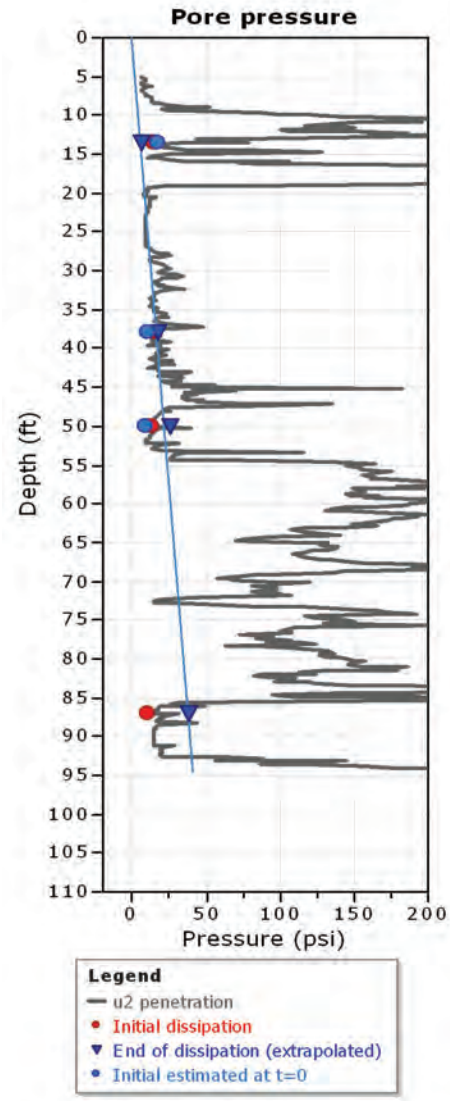

Piezocone Dissipation Test: 040RI-3
Depth: 38.06 (ft)
Porepressure u2 (psi)
t^0.50 (s^0.50)
u0 = 17.85 (psi)
u initial dissipation
assumed initial pore pressure, ui
1.941


Pore pressure
Depth (ft)
Pressure (psi)
Legend
u2 penetration
Initial dissipation
End of dissipation (extrapolated)
Initial estimated at t=0


Piezocone Dissipation Test: 040RI-3
Depth: 50.03 (ft)
Porepressure u2 (psi)
t^0.50 (s^0.50)
u0 = 26.01 (psi)
u initial dissipation
assumed initial pore pressure, ui
1.849


Pore pressure
Depth (ft)
Pressure (psi)
Legend
u2 penetration
Initial dissipation
End of dissipation (extrapolated)
Initial estimated at t=0


Piezocone Dissipation Test: 040RI-3
Depth: 87.11 (ft)
u0 = 37.77 (psi)
u initial dissipation
1.848
Porepressure u2 (psi)
t^0.50 (s^0.50)


Pore pressure
Depth (ft)
Pressure (psi)
Legend
u2 penetration
Initial dissipation
End of dissipation (extrapolated)
Initial estimated at t=0

Dissipation Tests Results

Dissipation tests

Dissipation tests consists of stopping the piezocone penetration and observing porepressures (u) with elapsed time (t). The data are automatic recorded by the field computer and should take place until a minimum of 50% dissipation.

The porepressures are plotted as a function of square root of (t). The graphical technique suggested by Robertson and Campanella (1989), yields a value for t_{50}, which corresponds to the time for 50% consolidation.

The value of the coefficient of consolidation in the radial or horizontal direction c_h was then calculated by Houlsby and Teh's (1988) theory using the following equation:

$$c_h = \frac{T \times r^2 \times I_r^{0.5}}{t_{50}}$$

where:

T: time factor given by Houlsby and Teh's (1988) theory corresponding to the porepressure position
r: piezocone radius
I_r: stiffness index, equal to shear modulus G divided by the undrained strength of clay (S_u).
t_{50}: time corresponding to 50% consolidation

Permeability estimates based on dissipation test

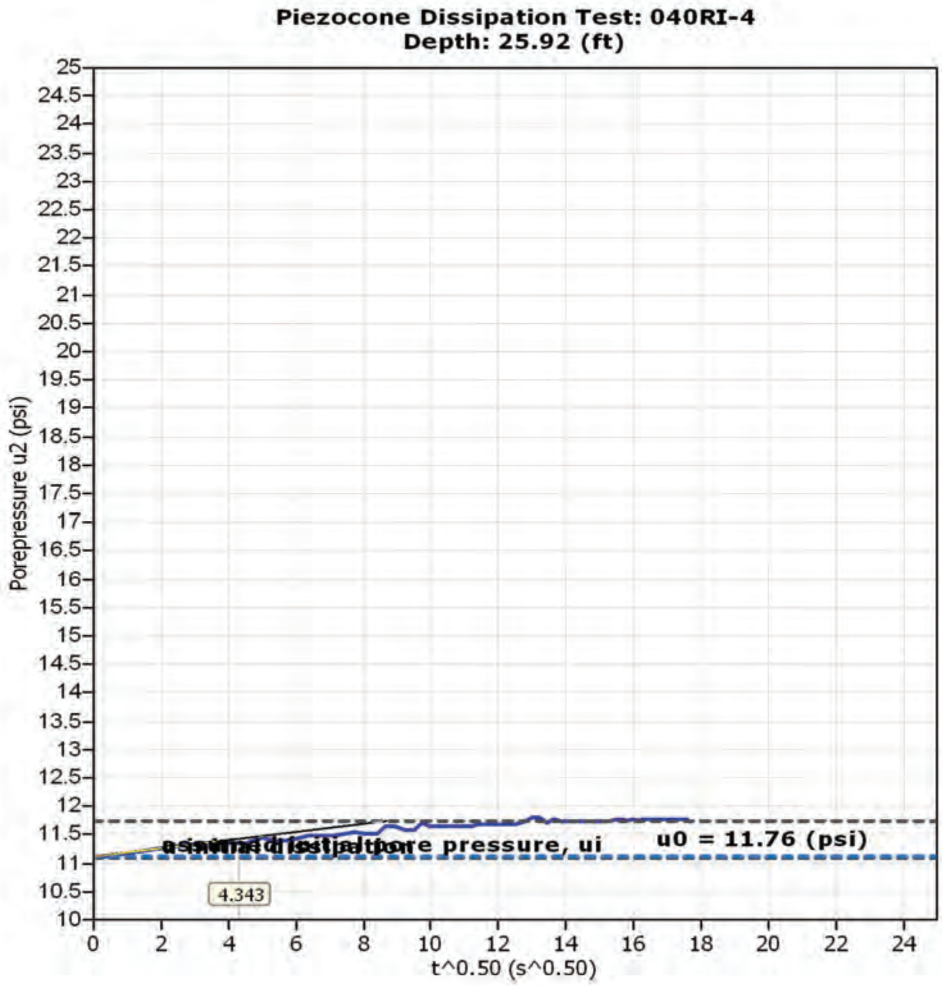
The dissipation of pore pressures during a CPTu dissipation test is controlled by the coefficient of consolidation in the horizontal direction (c_h) which is influenced by a combination of the soil permeability (k_h) and compressibility (M), as defined by the following:

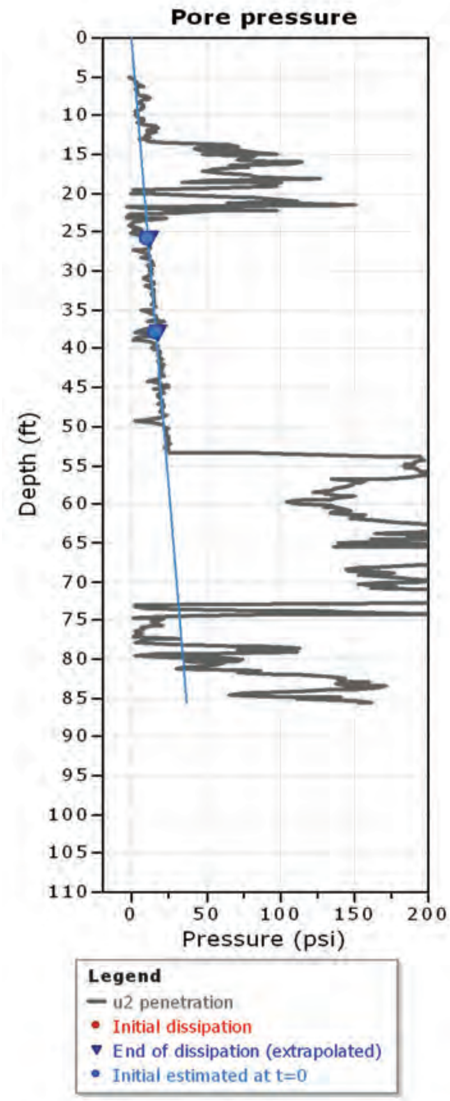
$$k_h = c_h \times \gamma_w / M$$

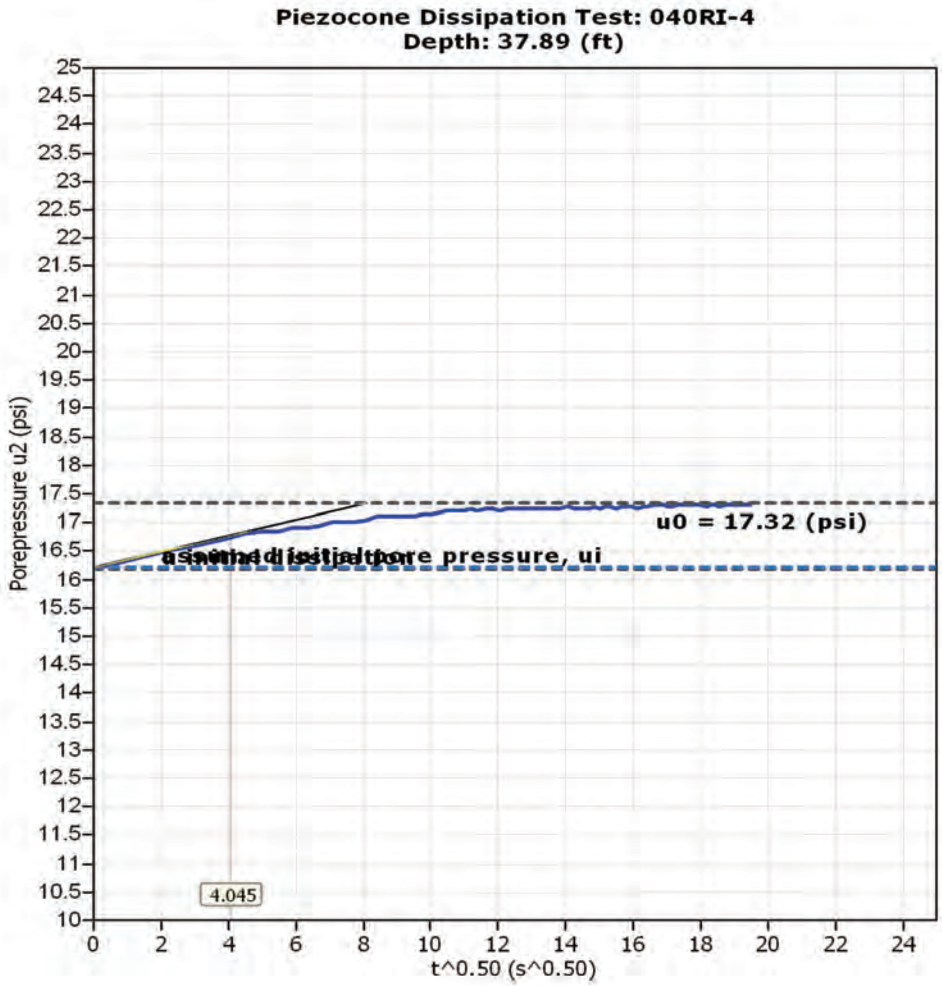
where: M is the 1-D constrained modulus and γ_w is the unit weight of water, in compatible units.

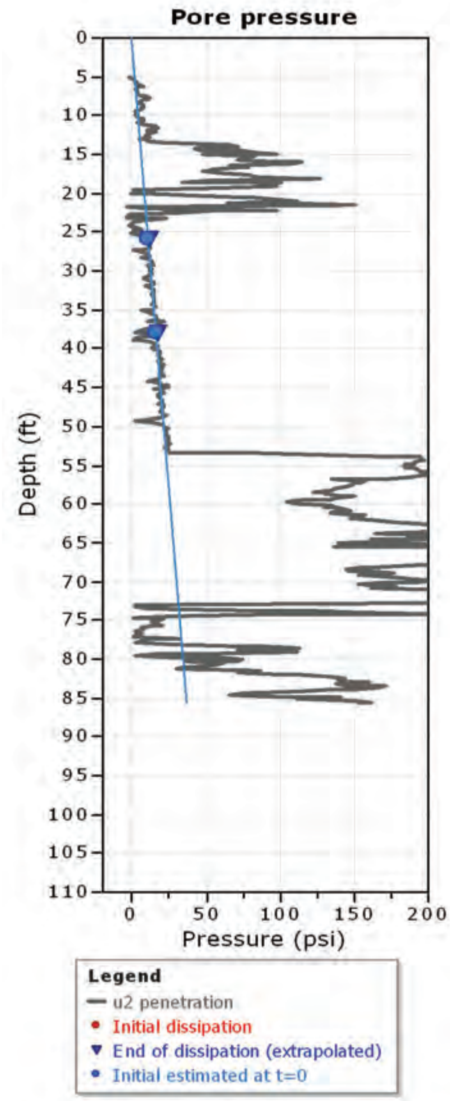
Tabular results

CPTU Borehole	Depth (ft)	$(t_{50})^{0.50}$	t_{50} (s)	t_{50} (years)	G/S_u	c_h (ft^2/s)	c_h ($ft^2/year$)	M (tsf)	k_h (ft/s)
040RI-4	25.92	4.3	19	5.98E-007	500.00	1.51E-003	47487	1000.00	4.70E-008
040RI-4	37.89	4.0	16	5.19E-007	500.00	1.74E-003	54733	1000.00	5.42E-008


Piezocone Dissipation Test: 040RI-4
Depth: 25.92 (ft)
Porepressure u2 (psi)
t^0.50 (s^0.50)
u0 = 11.76 (psi)
Initial dissipation pore pressure, ui
4.343


Pore pressure
Depth (ft)
Pressure (psi)
Legend
u2 penetration
Initial dissipation
End of dissipation (extrapolated)
Initial estimated at t=0


Piezocone Dissipation Test: 040RI-4
Depth: 37.89 (ft)
Porepressure u2 (psi)
t^0.50 (s^0.50)
u0 = 17.32 (psi)
assumed initial pore pressure, ui
4.045


Pore pressure
Depth (ft)
Pressure (psi)
Legend
u2 penetration
Initial dissipation
End of dissipation (extrapolated)
Initial estimated at t=0

Dissipation Tests Results

Dissipation tests

Dissipation tests consists of stopping the piezocone penetration and observing porepressures (u) with elapsed time (t). The data are automatic recorded by the field computer and should take place until a minimum of 50% dissipation.

The porepressures are plotted as a function of square root of (t). The graphical technique suggested by Robertson and Campanella (1989), yields a value for t_{50}, which corresponds to the time for 50% consolidation.

The value of the coefficient of consolidation in the radial or horizontal direction c_h was then calculated by Houlsby and Teh's (1988) theory using the following equation:

$$c_h = \frac{T \times r^2 \times I_r^{0.5}}{t_{50}}$$

where:

T: time factor given by Houlsby and Teh's (1988) theory corresponding to the porepressure position
r: piezocone radius
I_r: stiffness index, equal to shear modulus G divided by the undrained strength of clay (S_u).
t_{50}: time corresponding to 50% consolidation

Permeability estimates based on dissipation test

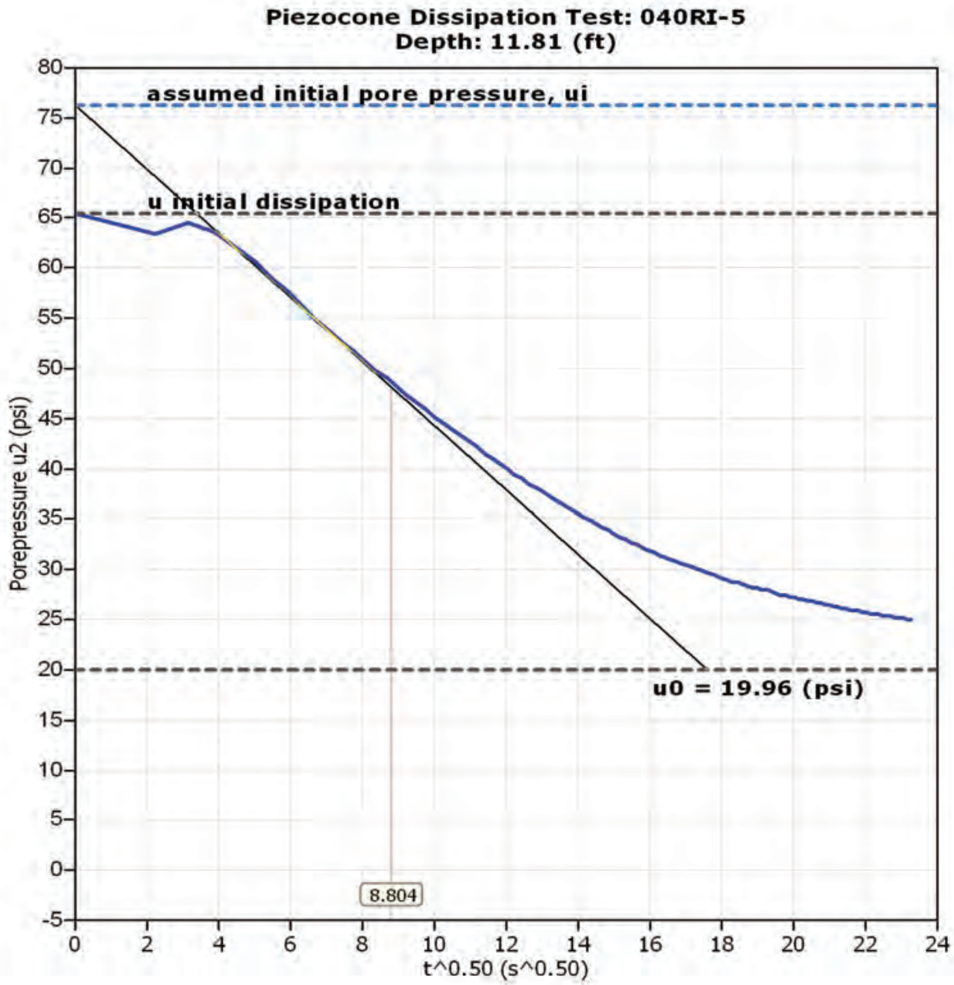
The dissipation of pore pressures during a CPTu dissipation test is controlled by the coefficient of consolidation in the horizontal direction (c_h) which is influenced by a combination of the soil permeability (k_h) and compressibility (M), as defined by the following:

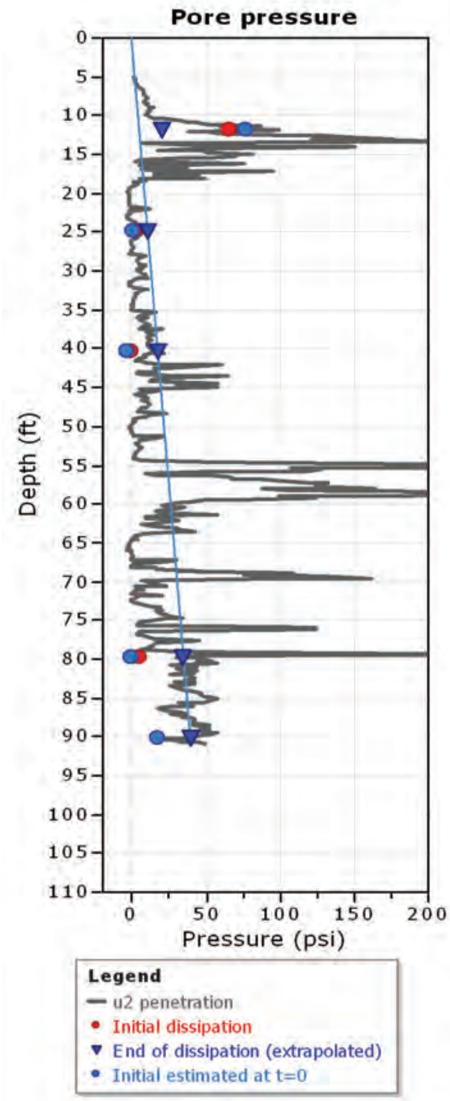
$$k_h = c_h \times \gamma_w / M$$

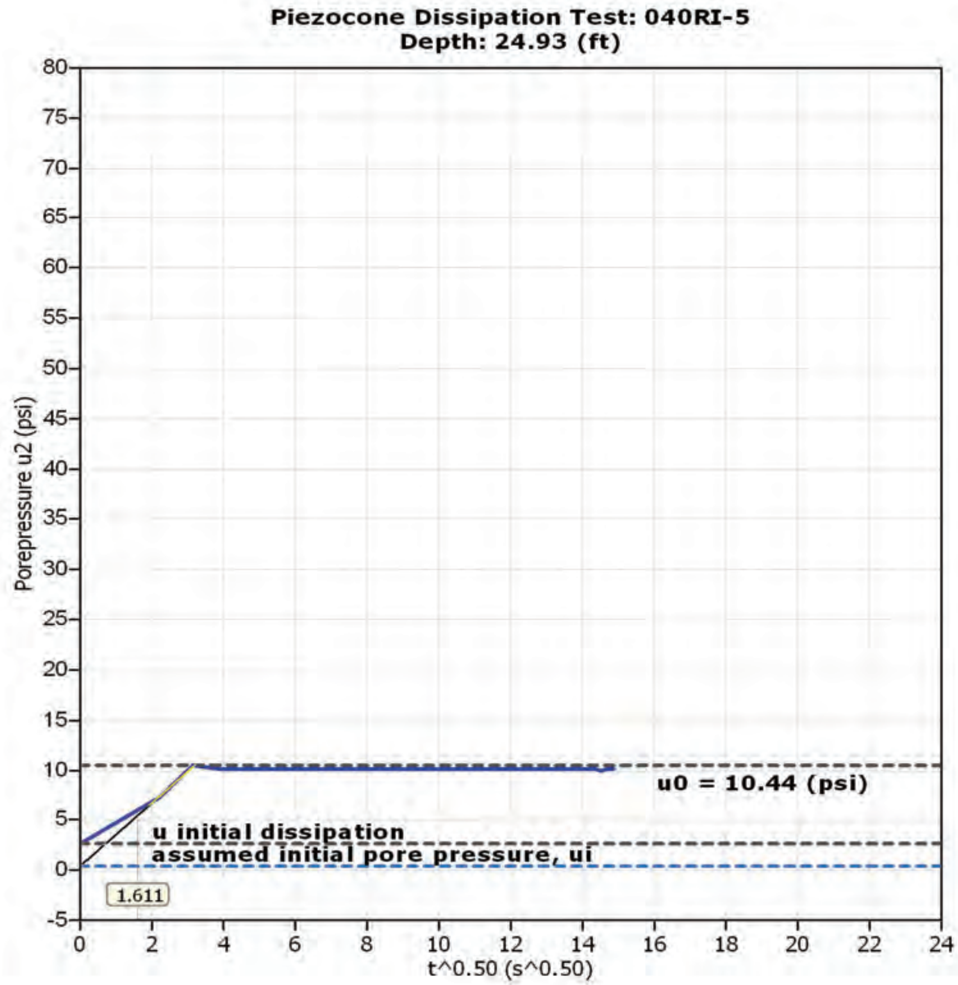
where: M is the 1-D constrained modulus and γ_w is the unit weight of water, in compatible units.

Tabular results

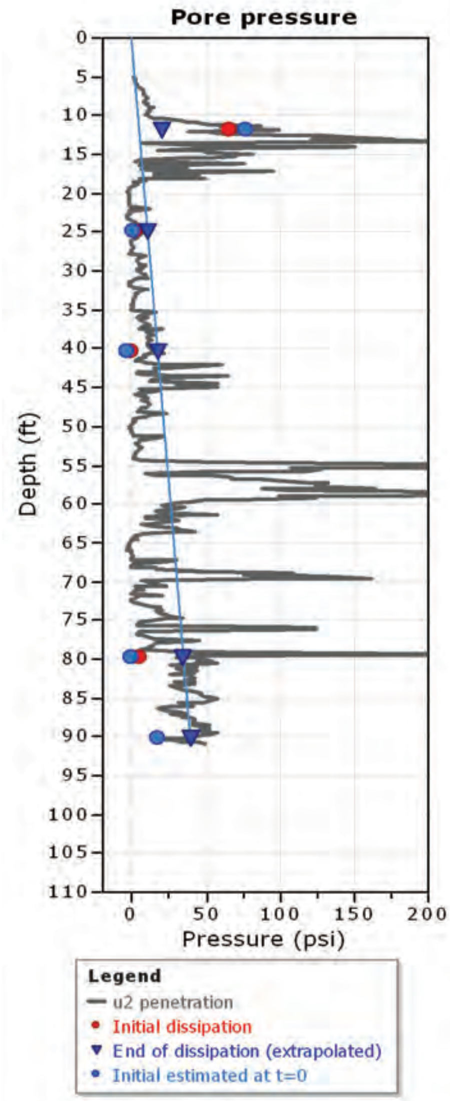
CPTU Borehole	Depth (ft)	$(t_{50})^{0.50}$	t_{50} (s)	t_{50} (years)	G/S_u	c_h (ft^2/s)	c_h ($ft^2/year$)	M (tsf)	k_h (ft/s)
040RI-5	11.81	8.8	78	2.46E-006	500.00	3.66E-004	11553	1000.00	1.14E-008
040RI-5	24.93	1.6	3	8.23E-008	500.00	1.09E-002	344893	1000.00	3.41E-007
040RI-5	40.35	1.9	4	1.20E-007	500.00	7.50E-003	236513	1000.00	2.34E-007
040RI-5	79.89	2.1	4	1.35E-007	500.00	6.66E-003	210071	1000.00	2.08E-007
040RI-5	90.06	1.2	1	4.43E-008	500.00	2.03E-002	641040	1000.00	6.35E-007


Piezocone Dissipation Test: 040RI-5
Depth: 11.81 (ft)
assumed initial pore pressure, ui
u initial dissipation
u0 = 19.96 (psi)
8.804
Porepressure u2 (psi)
t^0.50 (s^0.50)

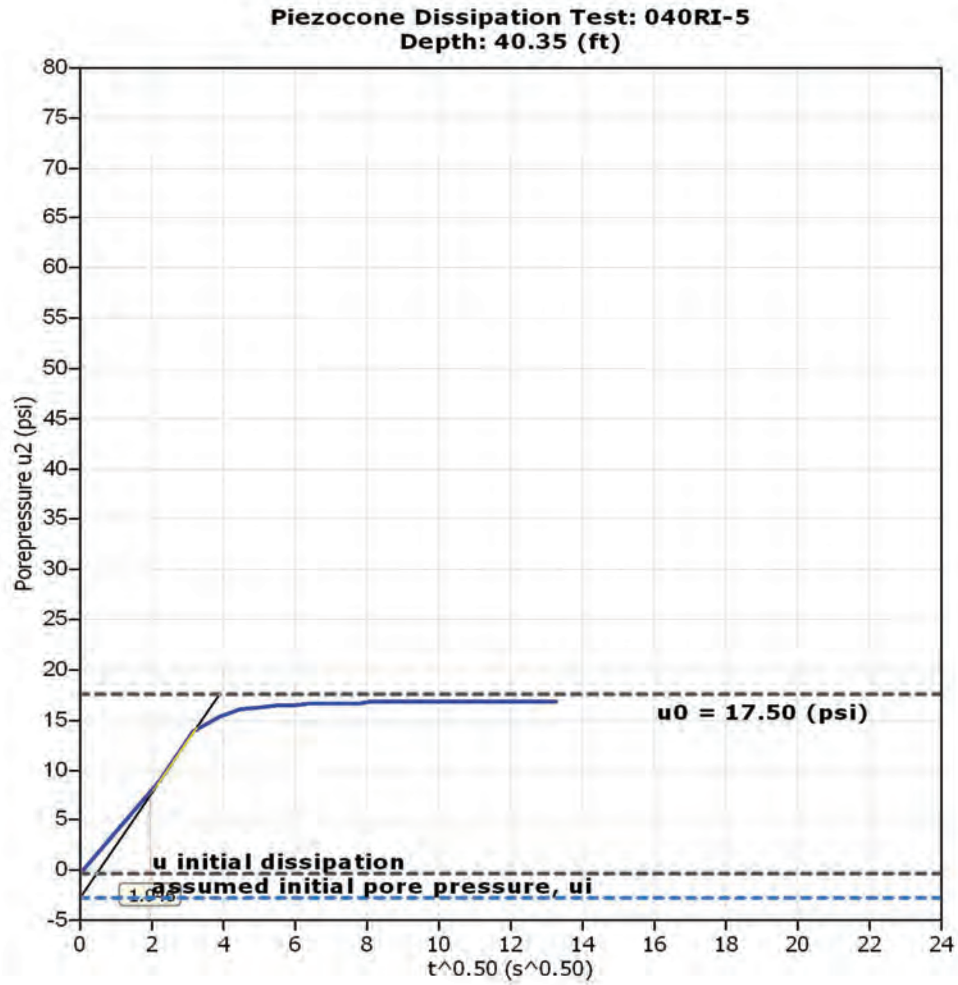

Pore pressure
Depth (ft)
Pressure (psi)
Legend
u2 penetration
Initial dissipation
End of dissipation (extrapolated)
Initial estimated at t=0

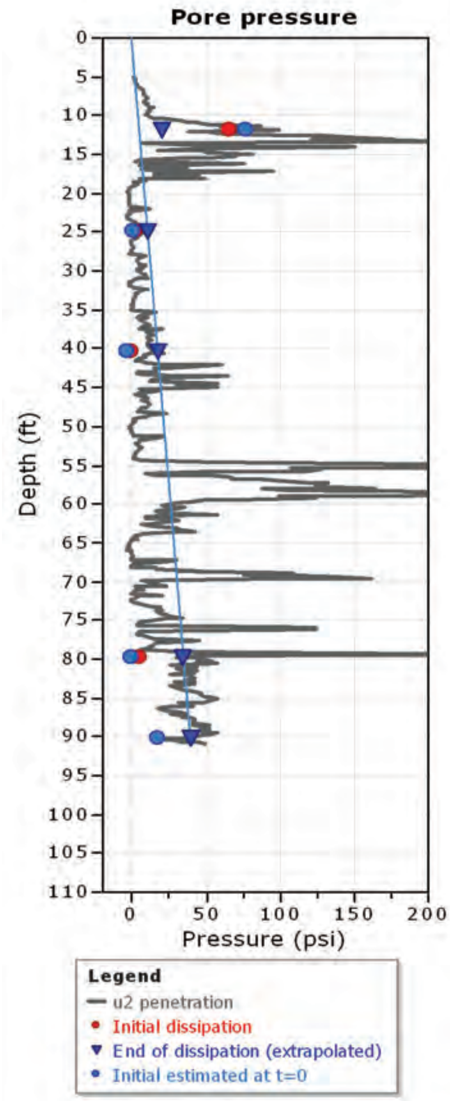


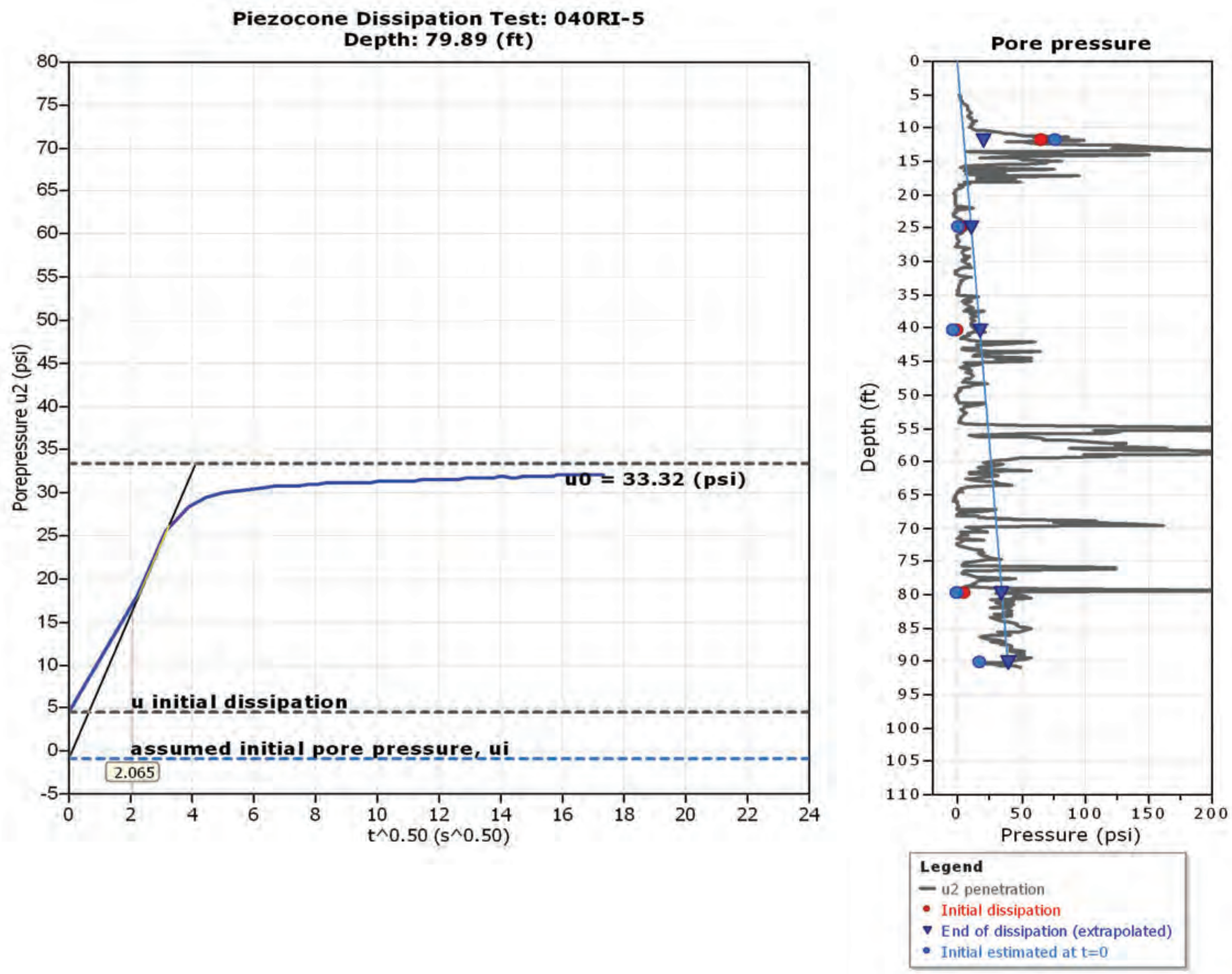
Piezocone Dissipation Test: 040RI-5
Depth: 24.93 (ft)
Porepressure u2 (psi)
t^0.50 (s^0.50)
u0 = 10.44 (psi)
u initial dissipation
assumed initial pore pressure, ui
1.611



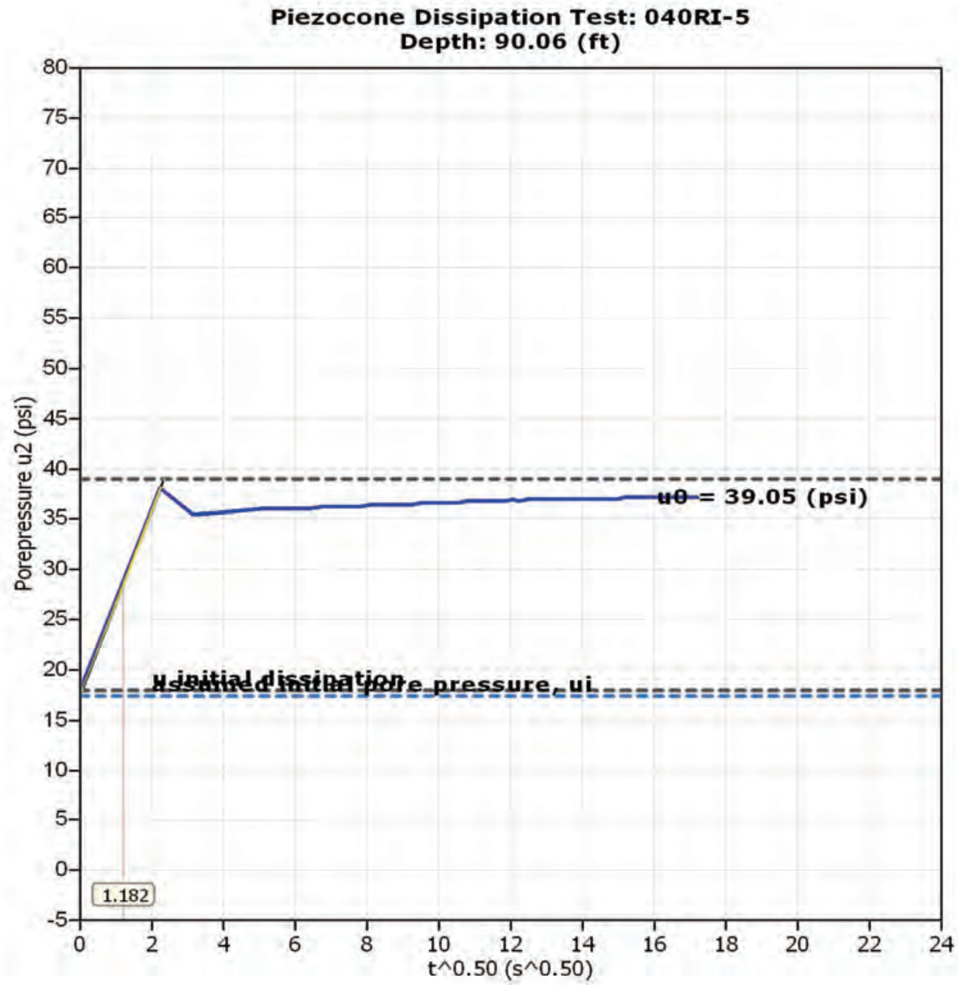
Pore pressure
Depth (ft)
Pressure (psi)
Legend
u2 penetration
Initial dissipation
End of dissipation (extrapolated)
Initial estimated at t=0

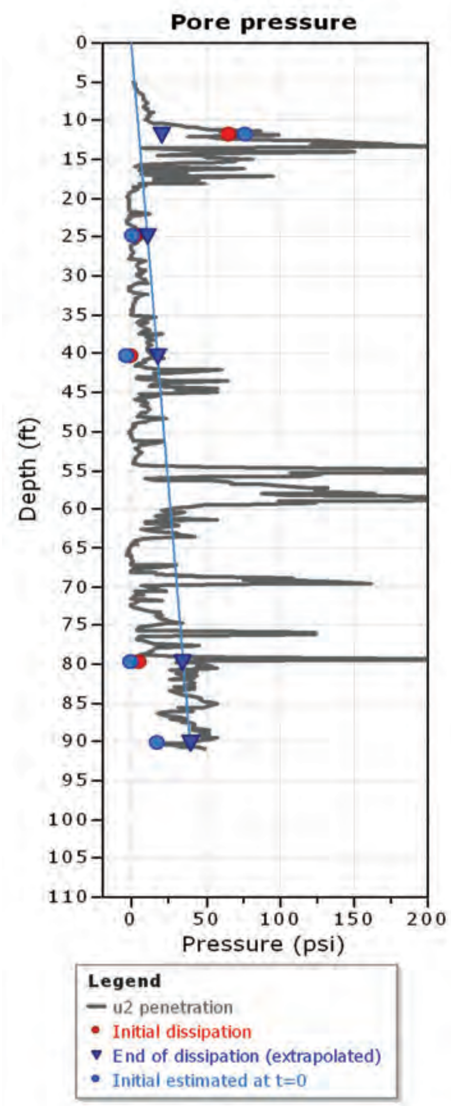

Piezocone Dissipation Test: 040RI-5
Depth: 40.35 (ft)
Porepressure u2 (psi)
t^0.50 (s^0.50)
u0 = 17.50 (psi)
u initial dissipation
assumed initial pore pressure, ui


Pore pressure
Depth (ft)
Pressure (psi)
Legend
u2 penetration
Initial dissipation
End of dissipation (extrapolated)
Initial estimated at t=0



Piezocone Dissipation Test: 040RI-5
Depth: 79.89 (ft)
Porepressure u2 (psi)
t^0.50 (s^0.50)
u0 = 33.32 (psi)
u initial dissipation
assumed initial pore pressure, ui
2.065
Pore pressure
Depth (ft)
Pressure (psi)
Legend
u2 penetration
Initial dissipation
End of dissipation (extrapolated)
Initial estimated at t=0


Piezocone Dissipation Test: 040RI-5
Depth: 90.06 (ft)
u0 = 39.05 (psi)
u initial dissipation
Assumed initial pore pressure, ui
1.182
Porepressure u2 (psi)
t^0.50 (s^0.50)


Pore pressure
Depth (ft)
Pressure (psi)
Legend
u2 penetration
Initial dissipation
End of dissipation (extrapolated)
Initial estimated at t=0

Dissipation Tests Results

Dissipation tests

Dissipation tests consists of stopping the piezocone penetration and observing porepressures (u) with elapsed time (t). The data are automatic recorded by the field computer and should take place until a minimum of 50% dissipation.

The porepressures are plotted as a function of square root of (t). The graphical technique suggested by Robertson and Campanella (1989), yields a value for t_{50}, which corresponds to the time for 50% consolidation.

The value of the coefficient of consolidation in the radial or horizontal direction c_h was then calculated by Houlsby and Teh's (1988) theory using the following equation:

$$c_h = \frac{T \times r^2 \times I_r^{0.5}}{t_{50}}$$

where:

T: time factor given by Houlsby and Teh's (1988) theory corresponding to the porepressure position
r: piezocone radius
I_r: stiffness index, equal to shear modulus G divided by the undrained strength of clay (S_u).
t_{50}: time corresponding to 50% consolidation

Permeability estimates based on dissipation test

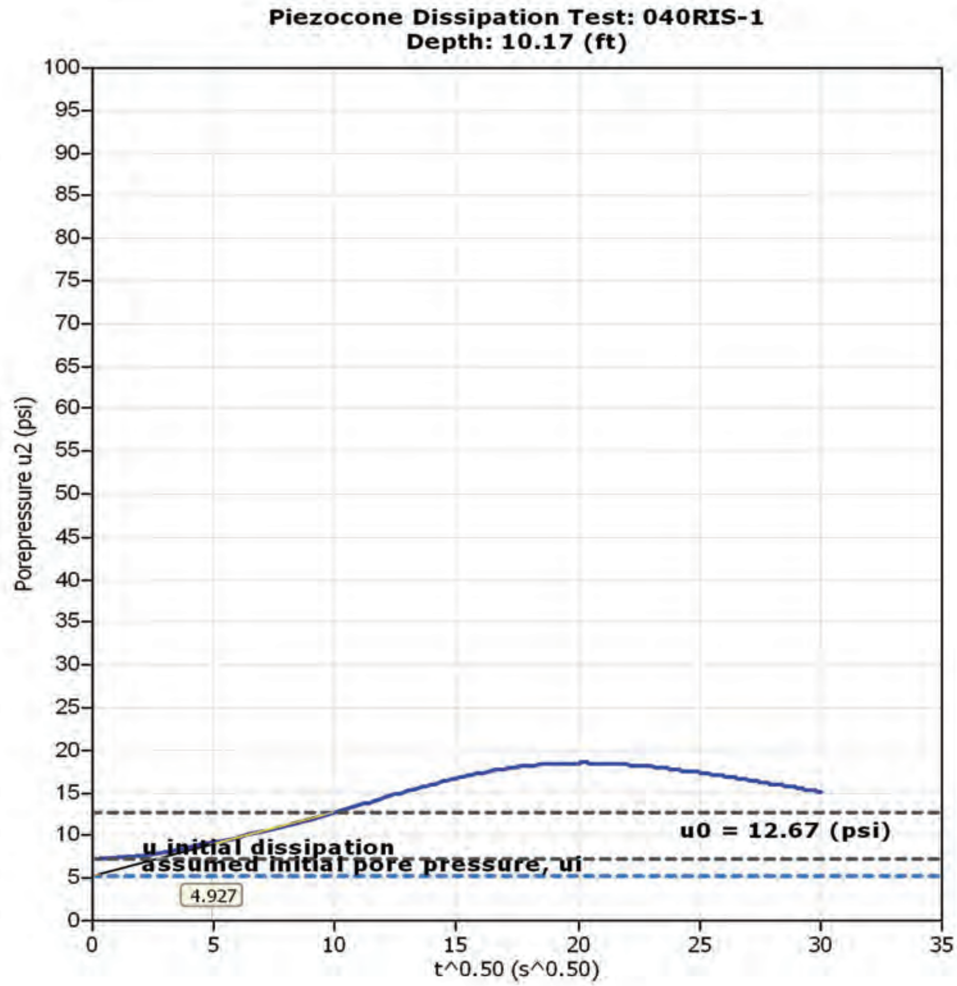
The dissipation of pore pressures during a CPTu dissipation test is controlled by the coefficient of consolidation in the horizontal direction (c_h) which is influenced by a combination of the soil permeability (k_h) and compressibility (M), as defined by the following:

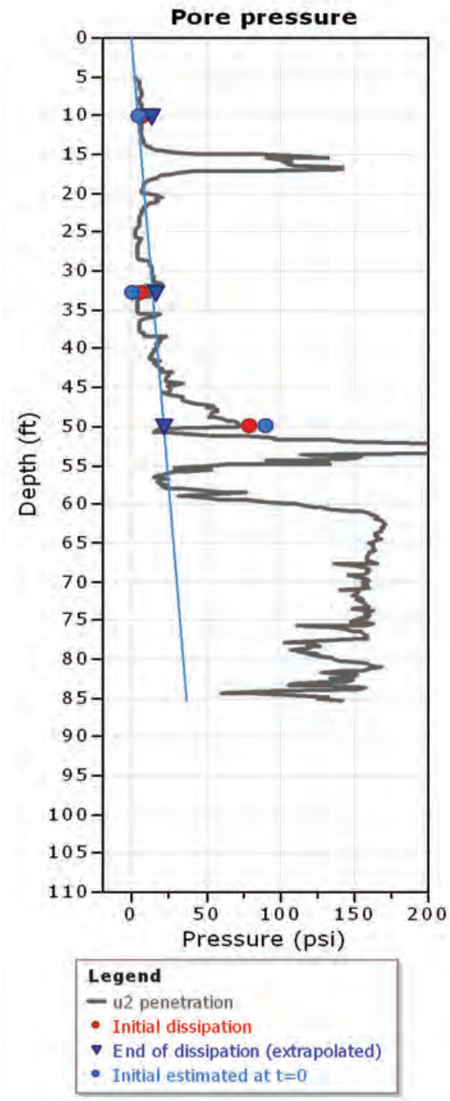
$$k_h = c_h \times \gamma_w / M$$

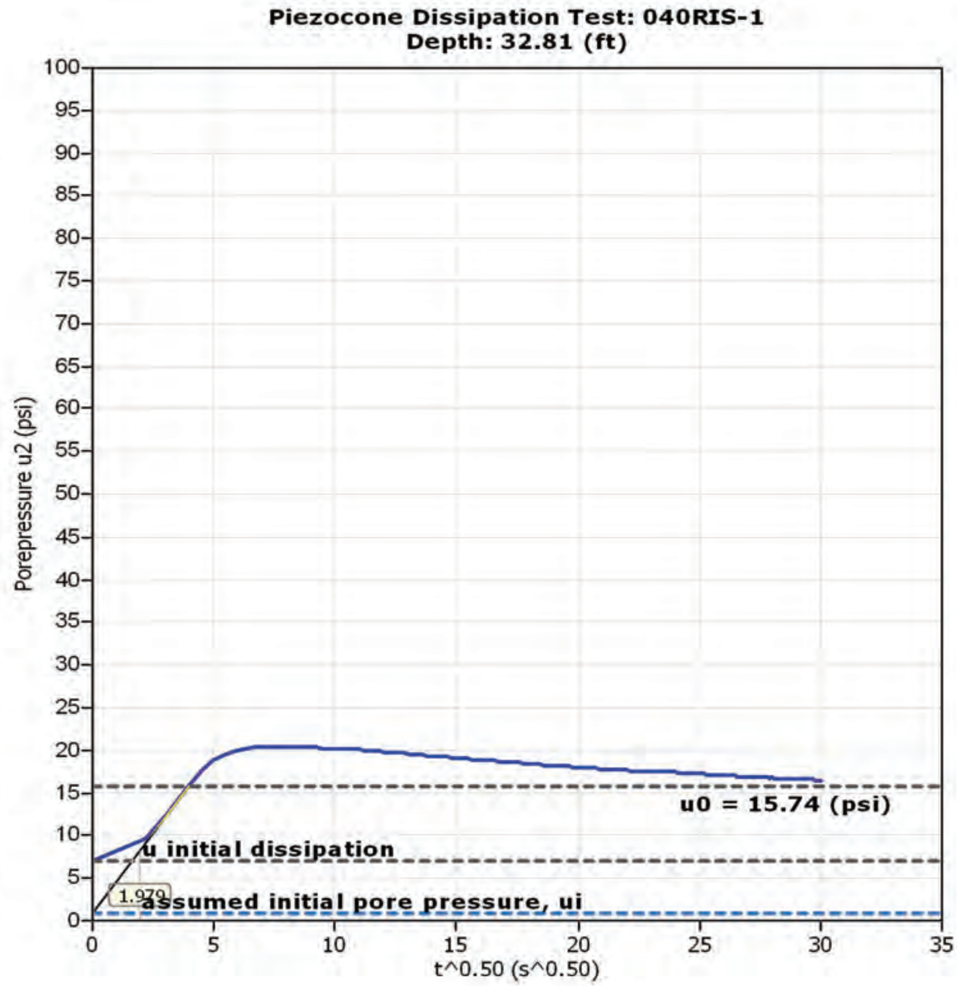
where: M is the 1-D constrained modulus and γ_w is the unit weight of water, in compatible units.

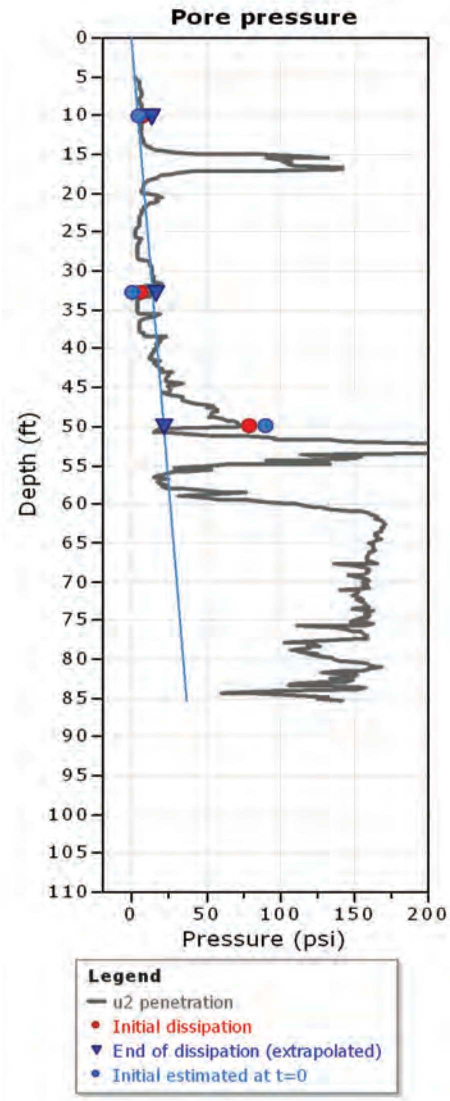
Tabular results

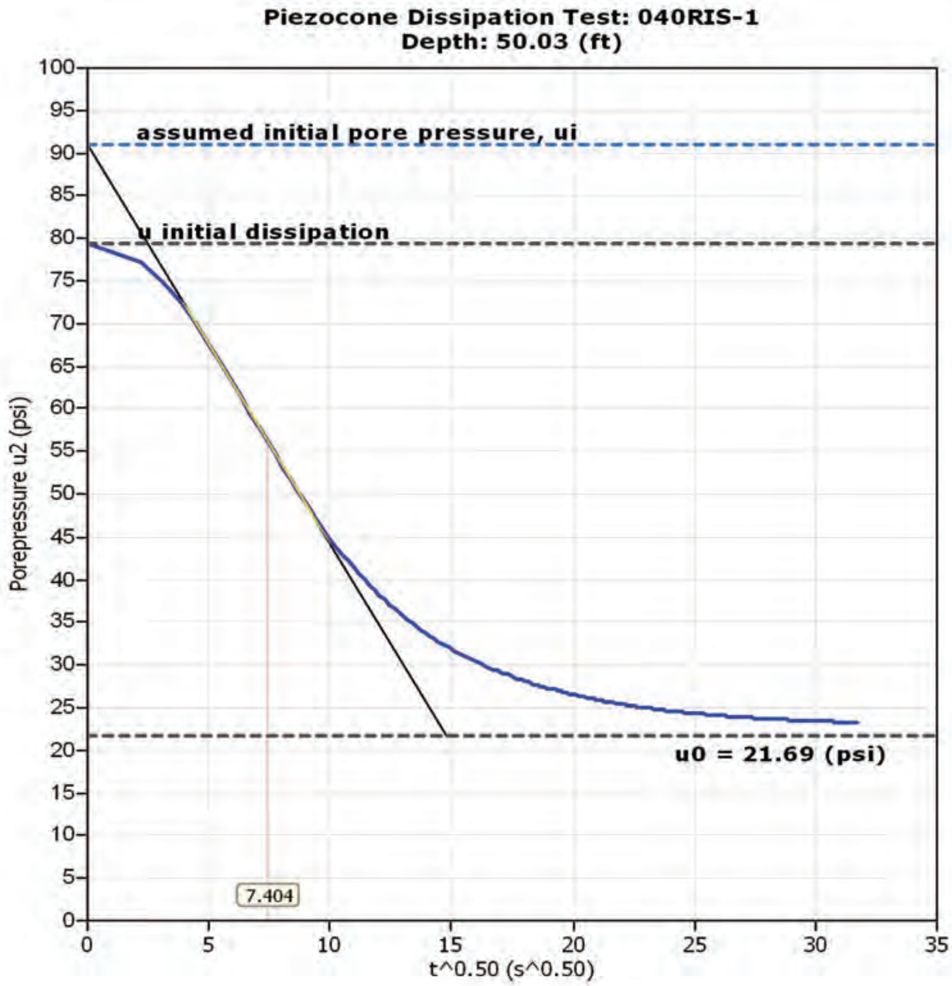
CPTU Borehole	Depth (ft)	$(t_{50})^{0.50}$	t_{50} (s)	t_{50} (years)	G/S_u	c_h (ft^2/s)	c_h ($ft^2/year$)	M (tsf)	k_h (ft/s)
040RIS-1	10.17	4.9	24	7.70E-007	500.00	1.17E-003	36894	1000.00	3.65E-008
040RIS-1	32.81	2.0	4	1.24E-007	500.00	7.25E-003	228656	1000.00	2.26E-007
040RIS-1	50.03	7.4	55	1.74E-006	500.00	5.18E-004	16338	1000.00	1.62E-008

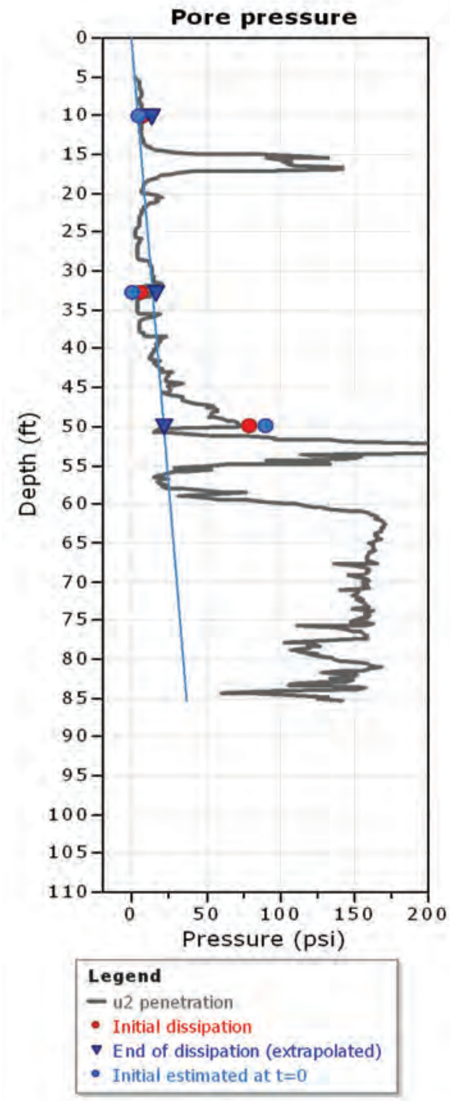

Piezocone Dissipation Test: 040RIS-1
Depth: 10.17 (ft)
Porepressure u2 (psi)
t^0.50 (s^0.50)
u initial dissipation
assumed initial pore pressure, ui
u0 = 12.67 (psi)
4.927


Pore pressure
Depth (ft)
Pressure (psi)
Legend
u2 penetration
Initial dissipation
End of dissipation (extrapolated)
Initial estimated at t=0


Piezocone Dissipation Test: 040RIS-1
Depth: 32.81 (ft)
Porepressure u2 (psi)
t^0.50 (s^0.50)
u0 = 15.74 (psi)
u initial dissipation
assumed initial pore pressure, ui
1.979


Pore pressure
Depth (ft)
Pressure (psi)
Legend
u2 penetration
Initial dissipation
End of dissipation (extrapolated)
Initial estimated at t=0


Piezocone Dissipation Test: 040RIS-1
Depth: 50.03 (ft)
assumed initial pore pressure, ui
u initial dissipation
u0 = 21.69 (psi)
7.404
Porepressure u2 (psi)
t^0.50 (s^0.50)


Pore pressure
Depth (ft)
Pressure (psi)
Legend
u2 penetration
Initial dissipation
End of dissipation (extrapolated)
Initial estimated at t=0

Dissipation Tests Results

Dissipation tests

Dissipation tests consists of stopping the piezocone penetration and observing porepressures (u) with elapsed time (t). The data are automatic recorded by the field computer and should take place until a minimum of 50% dissipation.

The porepressures are plotted as a function of square root of (t). The graphical technique suggested by Robertson and Campanella (1989), yields a value for t_{50}, which corresponds to the time for 50% consolidation.

The value of the coefficient of consolidation in the radial or horizontal direction c_h was then calculated by Houlsby and Teh's (1988) theory using the following equation:

$$c_h = \frac{T \times r^2 \times I_r^{0.5}}{t_{50}}$$

where:

T: time factor given by Houlsby and Teh's (1988) theory corresponding to the porepressure position
r: piezocone radius
I_r: stiffness index, equal to shear modulus G divided by the undrained strength of clay (S_u).
t_{50}: time corresponding to 50% consolidation

Permeability estimates based on dissipation test

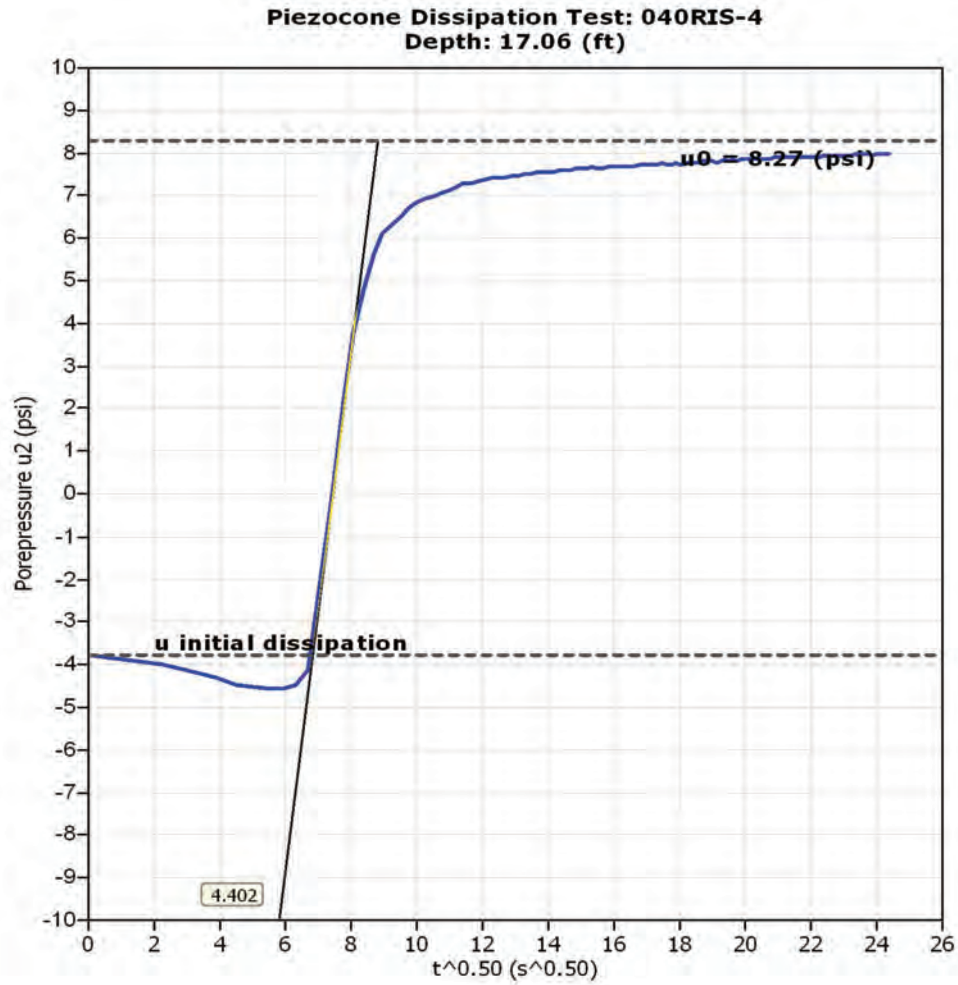
The dissipation of pore pressures during a CPTu dissipation test is controlled by the coefficient of consolidation in the horizontal direction (c_h) which is influenced by a combination of the soil permeability (k_h) and compressibility (M), as defined by the following:

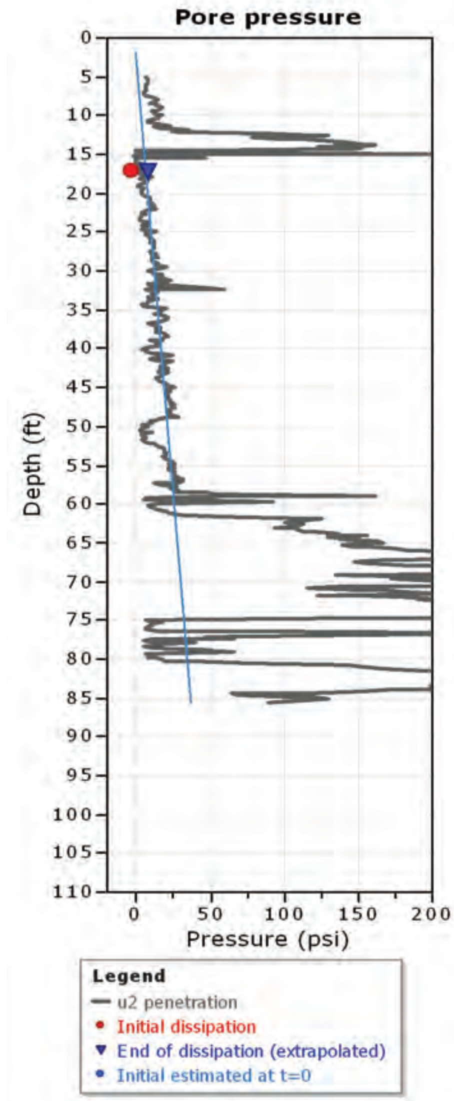
$$k_h = c_h \times \gamma_w / M$$

where: M is the 1-D constrained modulus and γ_w is the unit weight of water, in compatible units.

Tabular results

CPTU Borehole	Depth (ft)	$(t_{50})^{0.50}$	t_{50} (s)	t_{50} (years)	G/S_u	c_h (ft^2/s)	c_h ($ft^2/year$)	M (tsf)	k_h (ft/s)
040RIS-4	17.06	4.4	19	6.14E-007	500.00	1.47E-003	46221	1000.00	4.58E-008


Piezocone Dissipation Test: 040RIS-4
Depth: 17.06 (ft)
u0 = 8.27 (psi)
u initial dissipation
4.402
Porepressure u2 (psi)
t^0.50 (s^0.50)


Pore pressure
Depth (ft)
Pressure (psi)
Legend
u2 penetration
Initial dissipation
End of dissipation (extrapolated)
Initial estimated at t=0

Dissipation Tests Results

Dissipation tests

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$$c_h = \frac{T \times r^2 \times I_r^{0.5}}{t_{50}}$$

where:

T: time factor given by Houlsby and Teh's (1988) theory corresponding to the porepressure position
r: piezocone radius
I_r: stiffness index, equal to shear modulus G divided by the undrained strength of clay (S_u).
t_{50}: time corresponding to 50% consolidation

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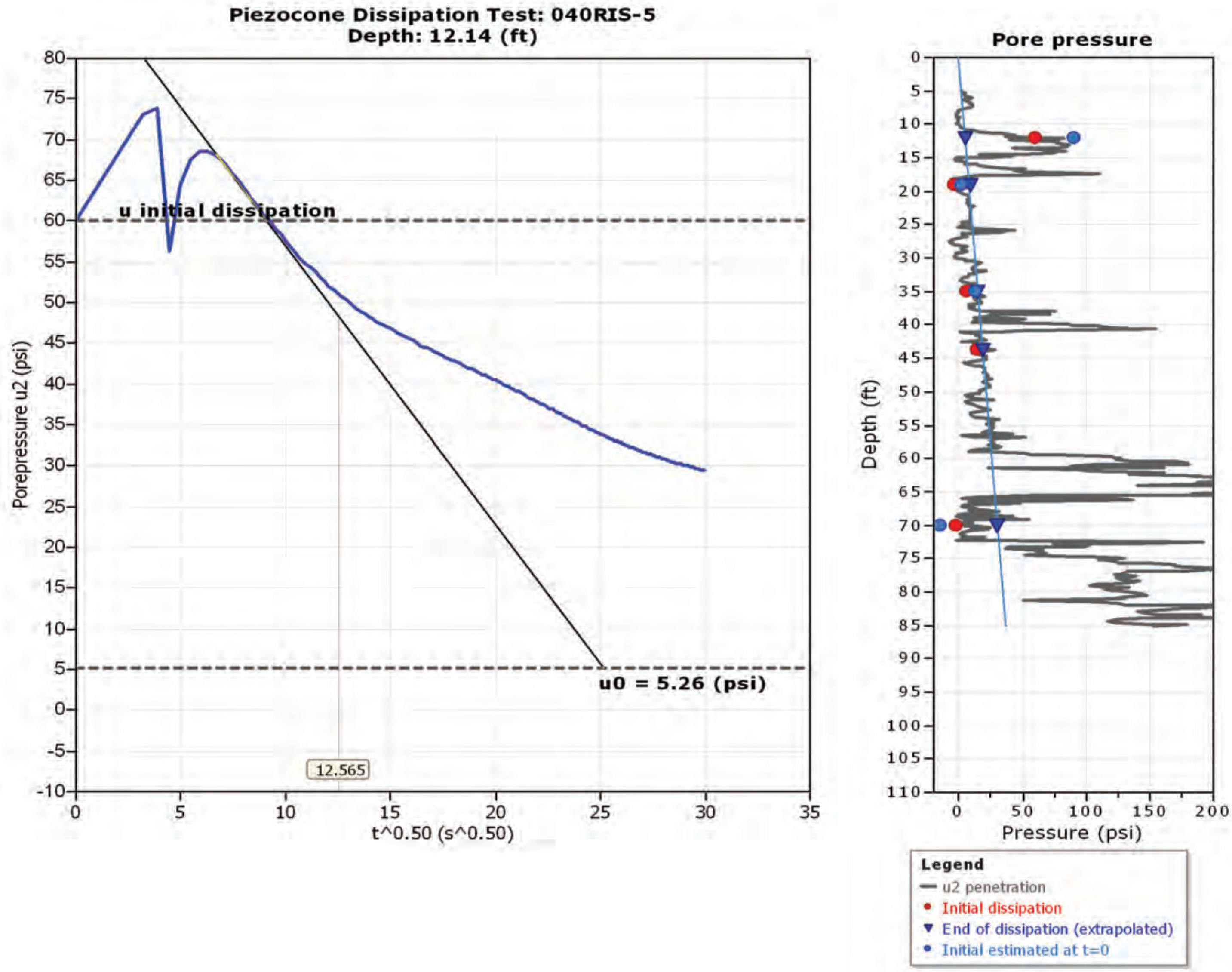
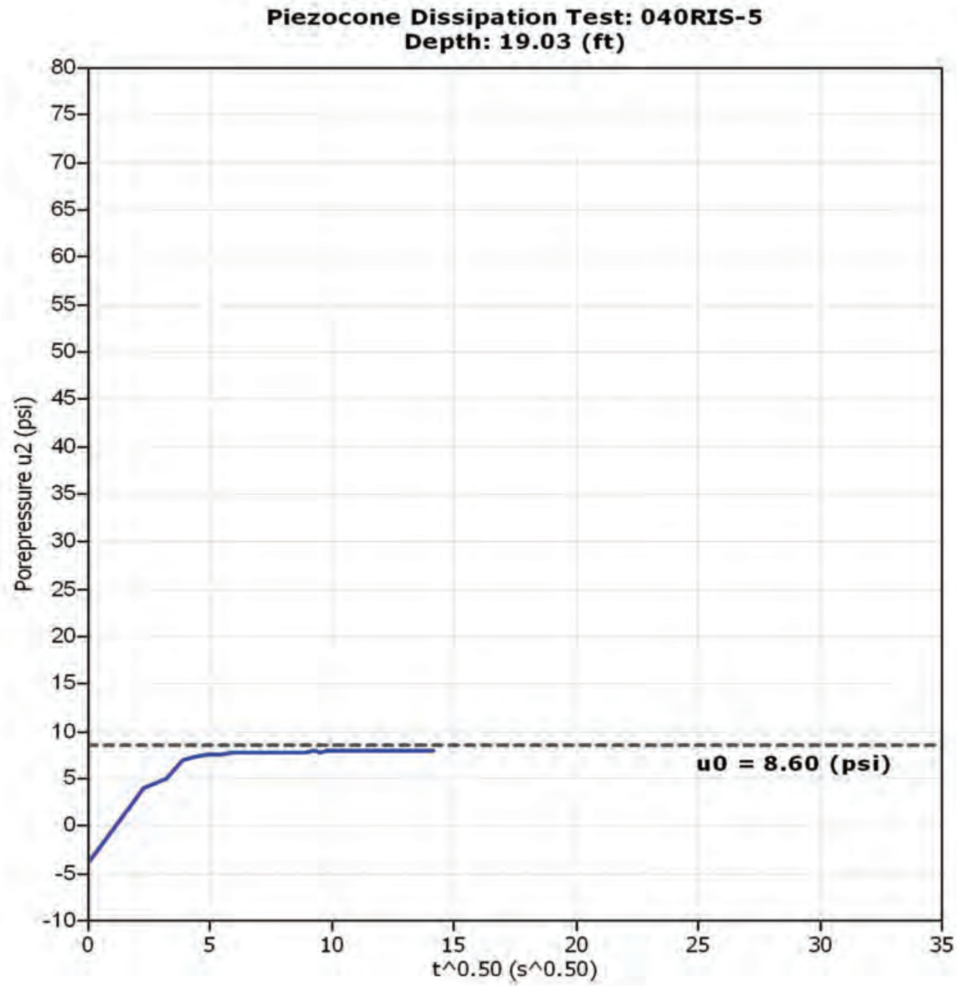
$$k_h = c_h \times \gamma_w / M$$

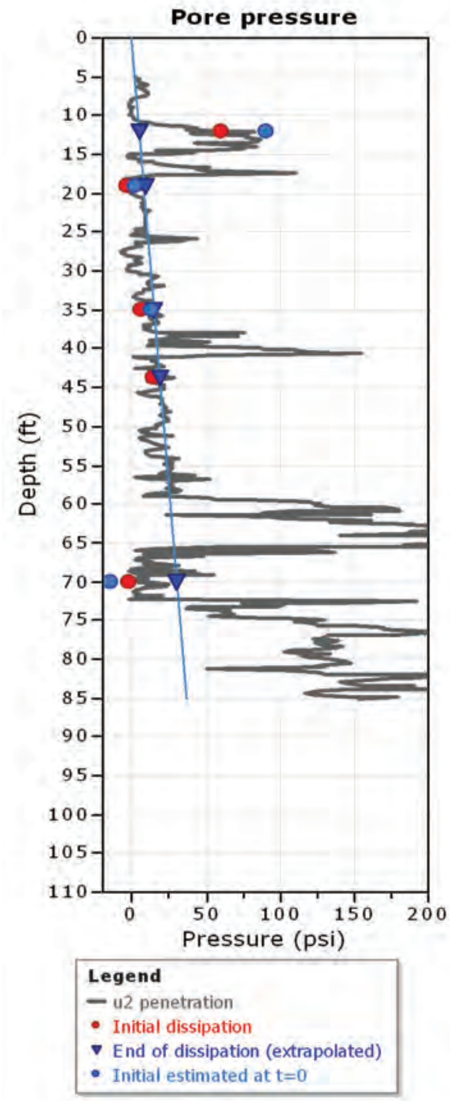
where: M is the 1-D constrained modulus and γ_w is the unit weight of water, in compatible units.

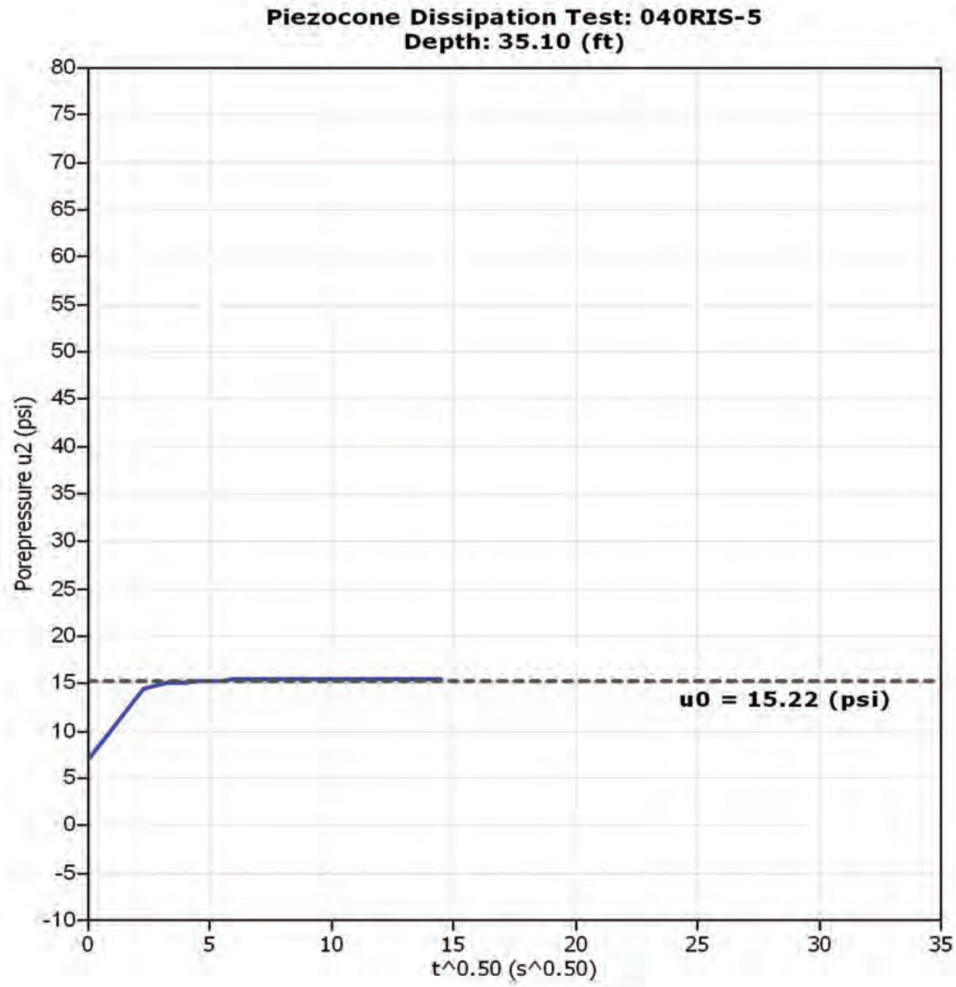
Tabular results

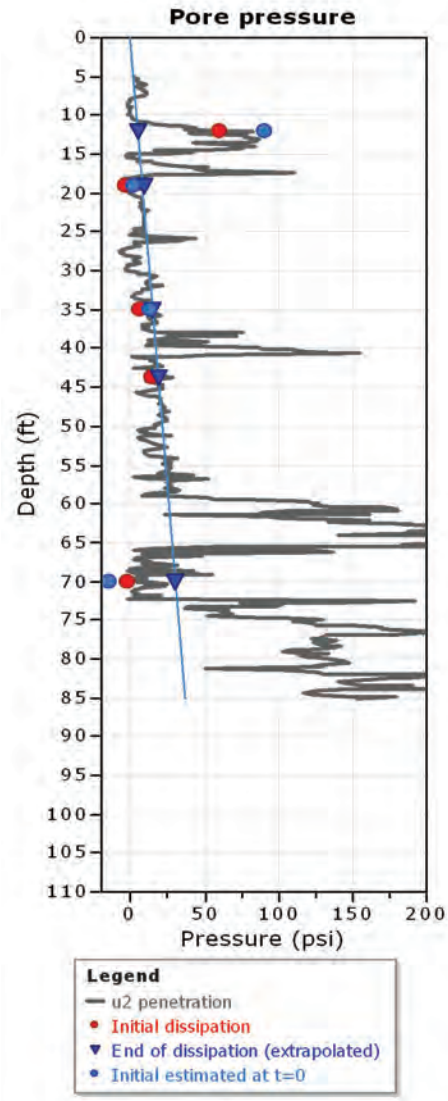
CPTU Borehole	Depth (ft)	$(t_{50})^{0.50}$	t_{50} (s)	t_{50} (years)	G/S_u	c_h (ft^2/s)	c_h ($ft^2/year$)	M (tsf)	k_h (ft/s)
040RIS-5	12.14	12.6	158	5.01E-006	500.00	1.80E-004	5673	1000.00	5.62E-009
040RIS-5	19.03	5.6	31	9.87E-007	500.00	9.13E-004	28780	1000.00	2.85E-008
040RIS-5	35.10	1.8	3	9.93E-008	500.00	9.06E-003	285861	1000.00	2.83E-007
040RIS-5	43.80	1.7	3	9.45E-008	500.00	9.53E-003	300444	1000.00	2.97E-007
040RIS-5	70.21	1.8	3	1.07E-007	500.00	8.44E-003	266213	1000.00	2.64E-007

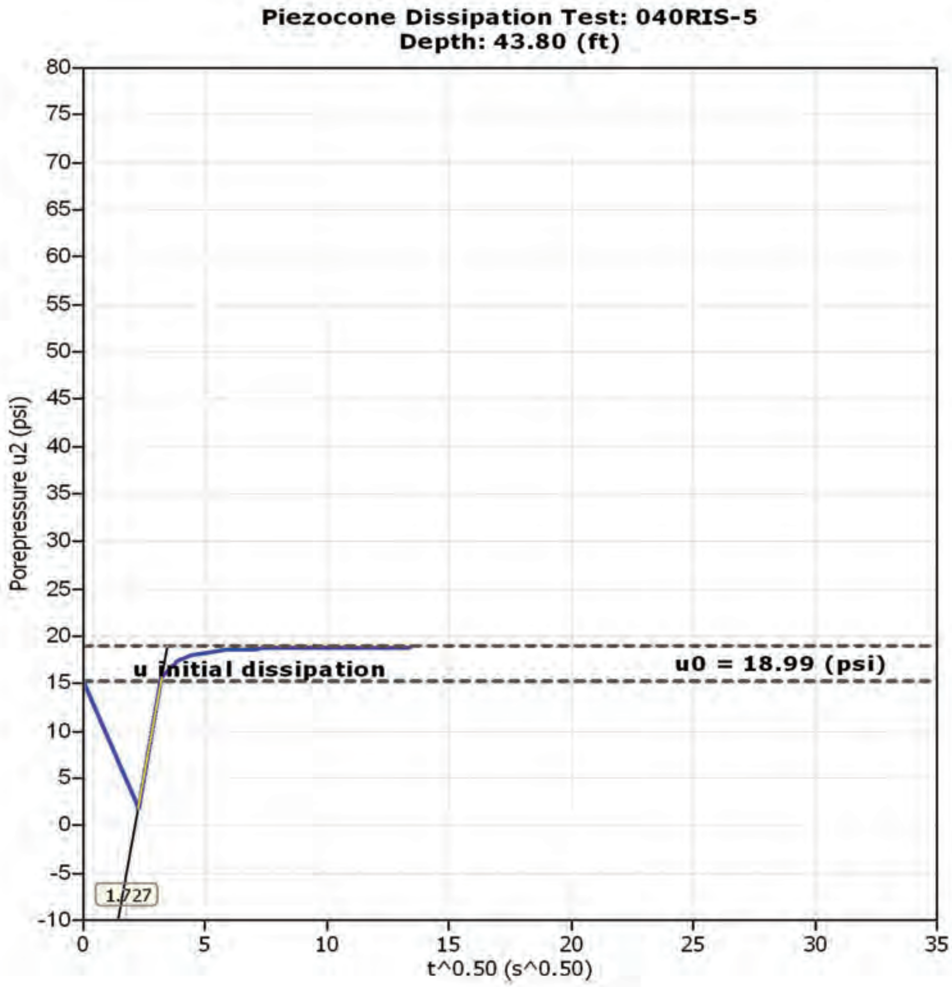

Piezocone Dissipation Test: 040RIS-5
Depth: 12.14 (ft)
u initial dissipation
u0 = 5.26 (psi)
12.565
Porepressure u2 (psi)
t^0.50 (s^0.50)
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
-5
-10
0
5
10
15
20
25
30
35
Pore pressure
Depth (ft)
Pressure (psi)
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
100
105
110
0
50
100
150
200
Legend
u2 penetration
Initial dissipation
End of dissipation (extrapolated)
Initial estimated at t=0


Piezocone Dissipation Test: 040RIS-5
Depth: 19.03 (ft)
Porepressure u2 (psi)
t^0.50 (s^0.50)
u0 = 8.60 (psi)

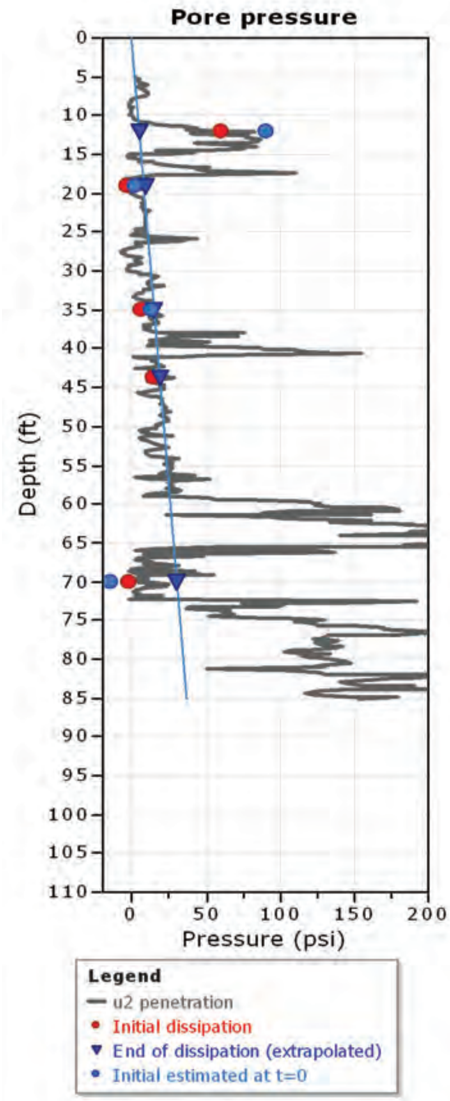

Pore pressure
Depth (ft)
Pressure (psi)
Legend
u2 penetration
Initial dissipation
End of dissipation (extrapolated)
Initial estimated at t=0


Piezocone Dissipation Test: 040RIS-5
Depth: 35.10 (ft)
Porepressure u2 (psi)
t^0.50 (s^0.50)
u0 = 15.22 (psi)

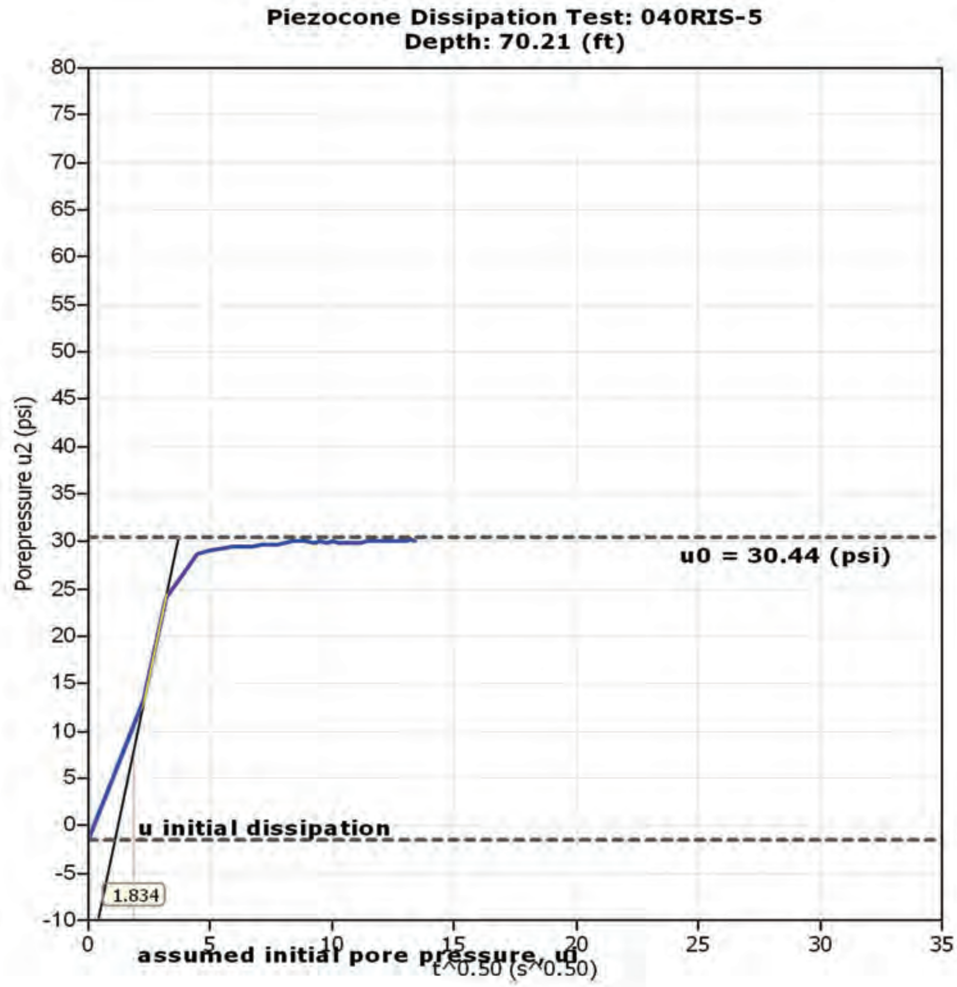

Pore pressure
Depth (ft)
Pressure (psi)
Legend
u2 penetration
Initial dissipation
End of dissipation (extrapolated)
Initial estimated at t=0

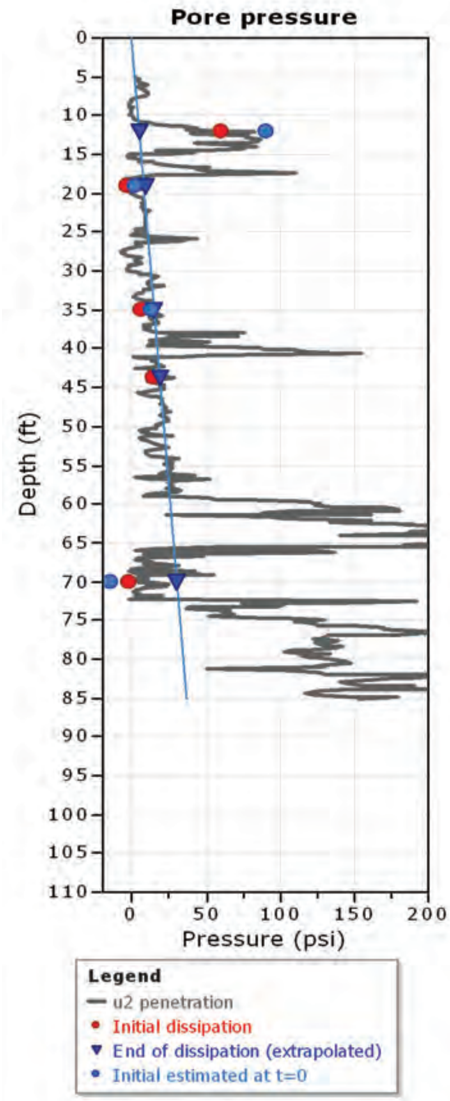


Piezocone Dissipation Test: 040RIS-5
Depth: 43.80 (ft)
Porepressure u2 (psi)
t^0.50 (s^0.50)
u initial dissipation
u0 = 18.99 (psi)
1.727



Pore pressure
Depth (ft)
Pressure (psi)
Legend
u2 penetration
Initial dissipation
End of dissipation (extrapolated)
Initial estimated at t=0


Piezocone Dissipation Test: 040RIS-5
Depth: 70.21 (ft)
Porepressure u2 (psi)
u0 = 30.44 (psi)
u initial dissipation
1.834
assumed initial pore pressure, ui
t^0.50 (s^0.50)


Pore pressure
Depth (ft)
Pressure (psi)
Legend
u2 penetration
Initial dissipation
End of dissipation (extrapolated)
Initial estimated at t=0

Dissipation Tests Results

Dissipation tests

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$$c_h = \frac{T \times r^2 \times I_r^{0.5}}{t_{50}}$$

where:

T: time factor given by Houlsby and Teh's (1988) theory corresponding to the porepressure position
r: piezocone radius
I_r: stiffness index, equal to shear modulus G divided by the undrained strength of clay (S_u).
t_{50}: time corresponding to 50% consolidation

Permeability estimates based on dissipation test

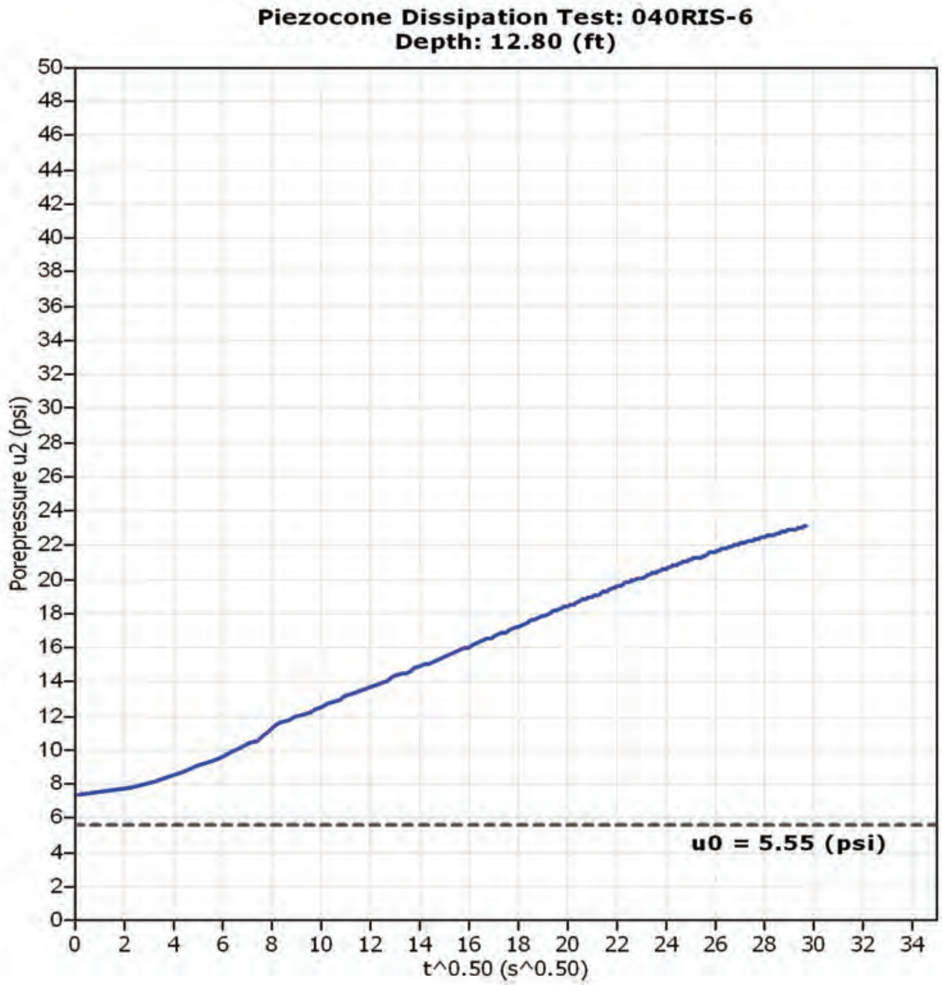
The dissipation of pore pressures during a CPTu dissipation test is controlled by the coefficient of consolidation in the horizontal direction (c_h) which is influenced by a combination of the soil permeability (k_h) and compressibility (M), as defined by the following:

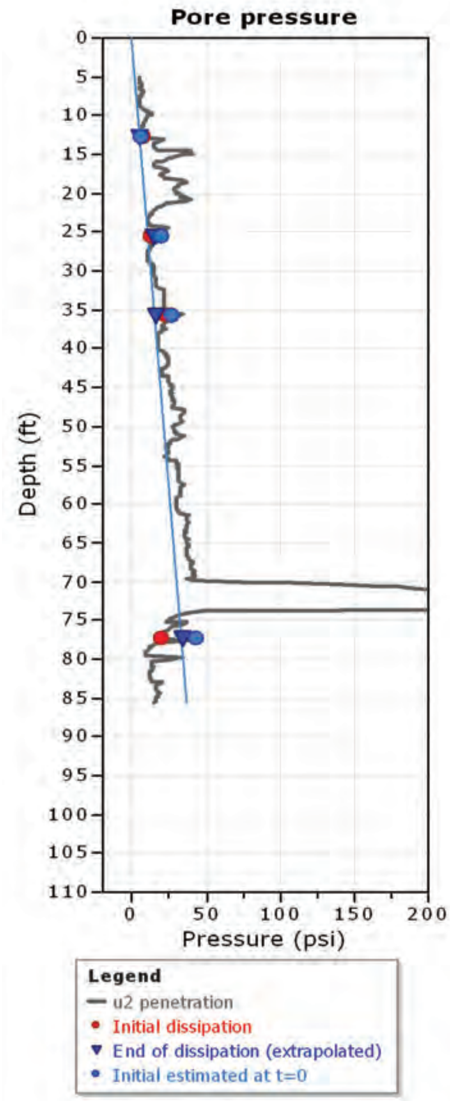
$$k_h = c_h \times \gamma_w / M$$

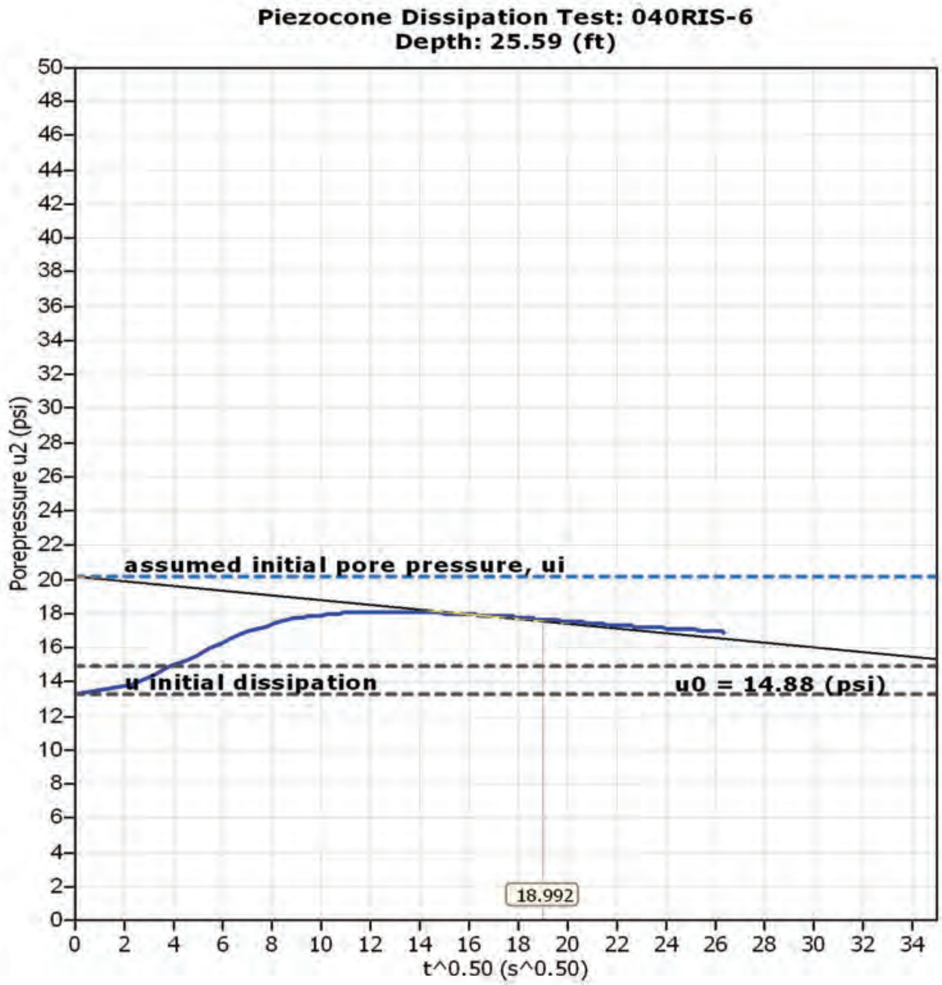
where: M is the 1-D constrained modulus and γ_w is the unit weight of water, in compatible units.

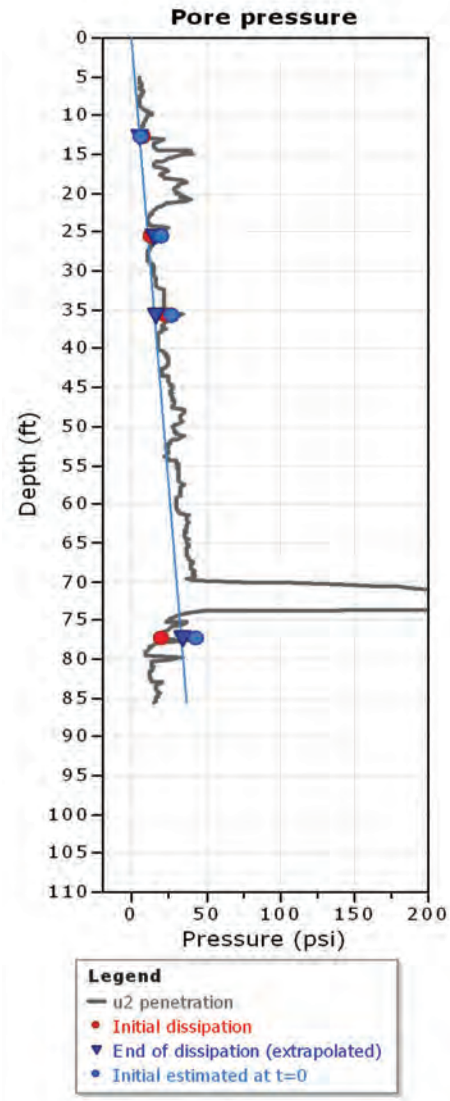
Tabular results

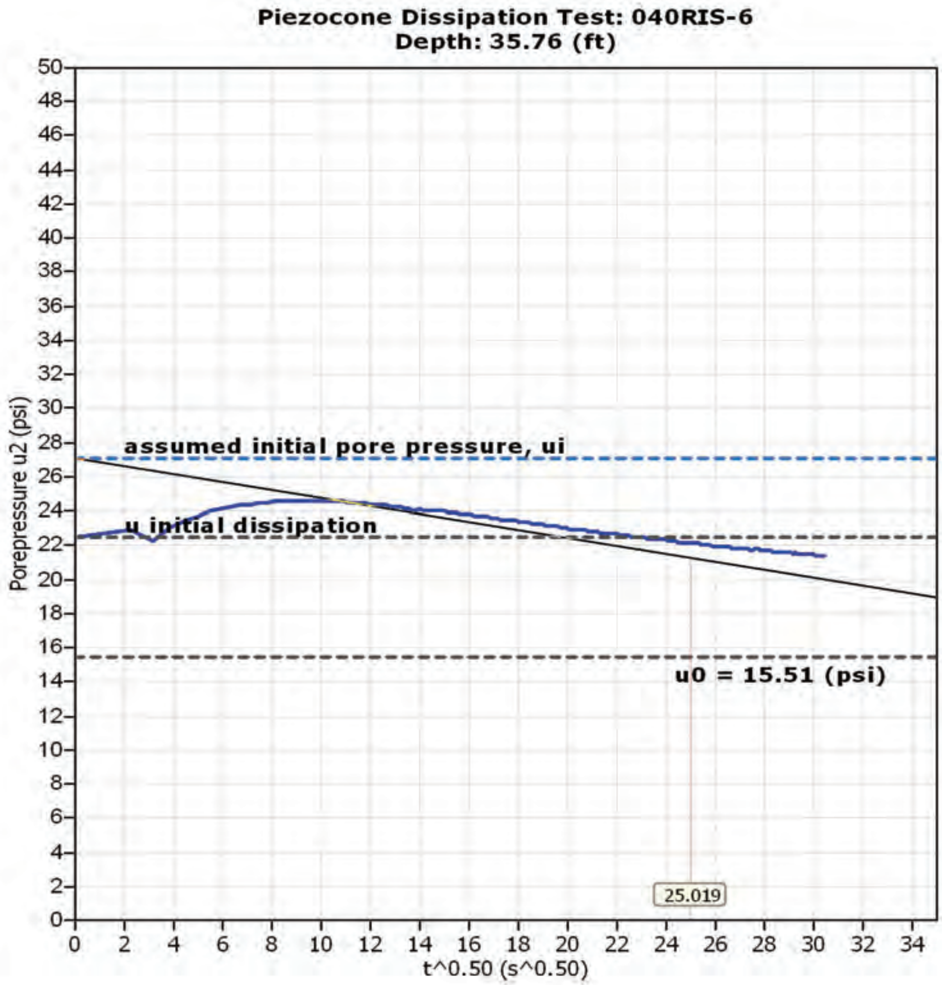
CPTU Borehole	Depth (ft)	$(t_{50})^{0.50}$	t_{50} (s)	t_{50} (years)	G/S_u	c_h (ft^2/s)	c_h ($ft^2/year$)	M (tsf)	k_h (ft/s)
040RIS-6	12.80	0.7	0	1.38E-008	500.00	6.51E-002	2053110	1000.00	2.03E-006
040RIS-6	25.59	19.0	361	1.14E-005	500.00	7.87E-005	2483	1000.00	2.46E-009
040RIS-6	35.76	25.0	626	1.98E-005	500.00	4.54E-005	1431	1000.00	1.42E-009
040RIS-6	77.43	15.9	254	8.04E-006	500.00	1.12E-004	3531	1000.00	3.50E-009

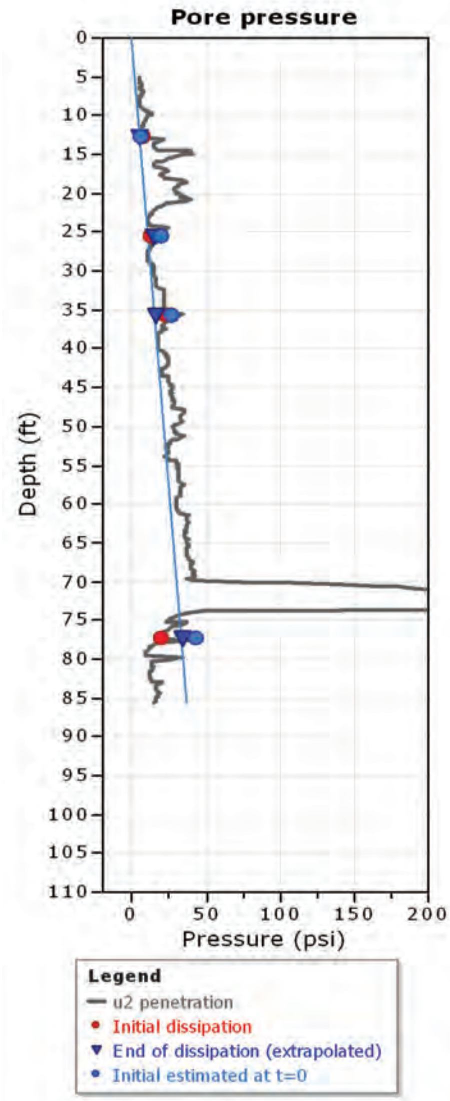

Piezocone Dissipation Test: 040RIS-6
Depth: 12.80 (ft)
Porepressure u2 (psi)
t^0.50 (s^0.50)
u0 = 5.55 (psi)

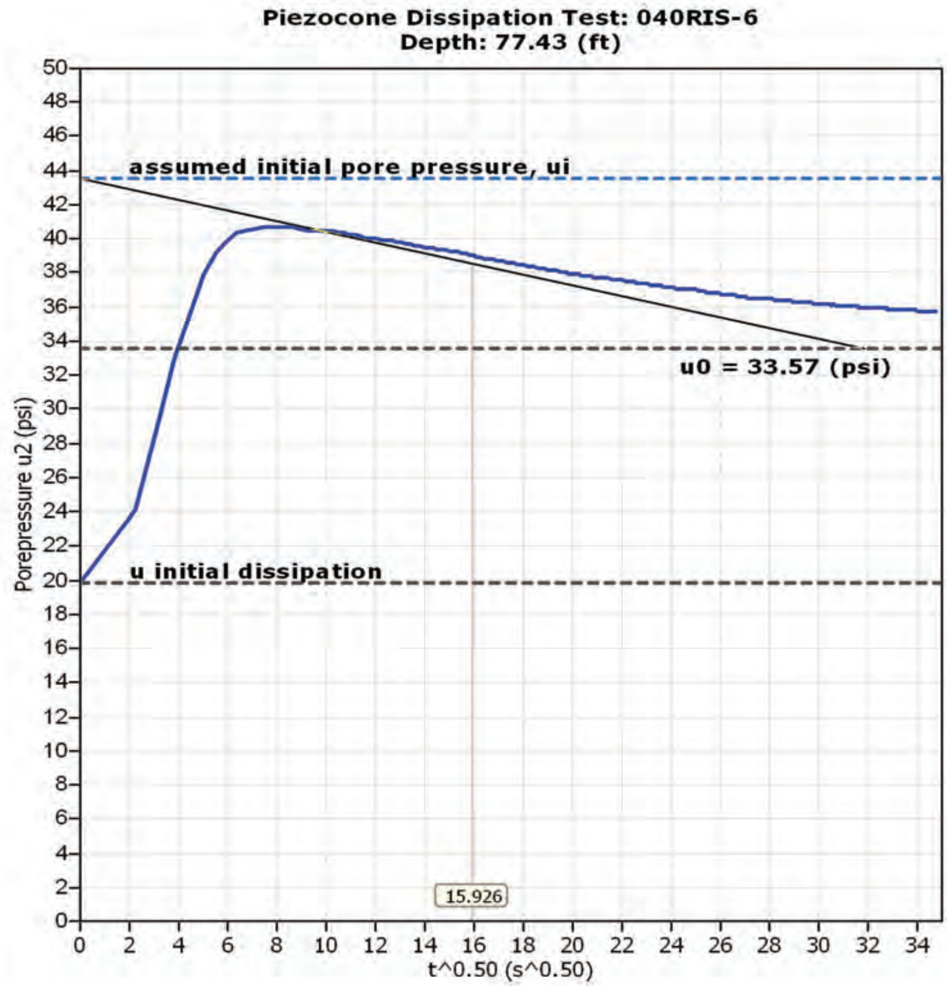

Pore pressure
Depth (ft)
Pressure (psi)
Legend
u2 penetration
Initial dissipation
End of dissipation (extrapolated)
Initial estimated at t=0

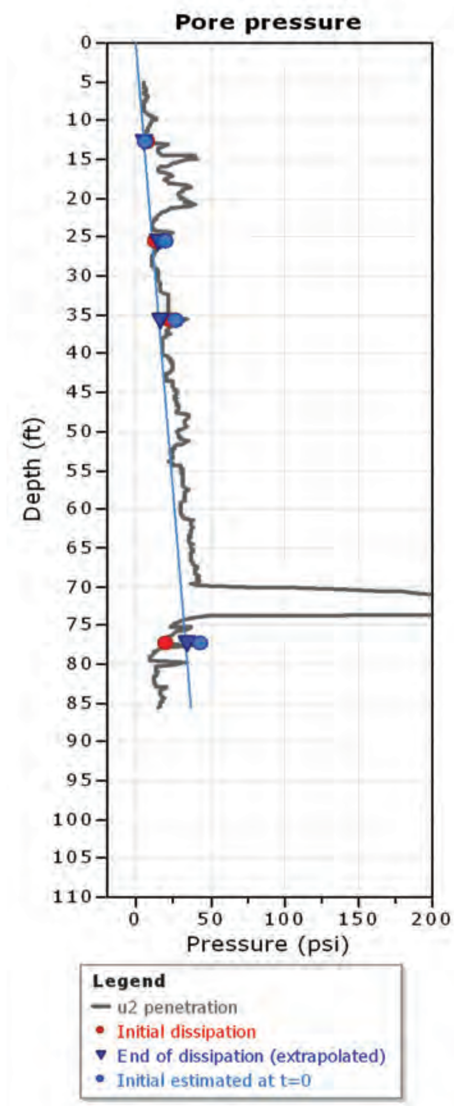

Piezocone Dissipation Test: 040RIS-6
Depth: 25.59 (ft)
Porepressure u2 (psi)
t^0.50 (s^0.50)
assumed initial pore pressure, ui
u initial dissipation
u0 = 14.88 (psi)
18.992


Pore pressure
Depth (ft)
Pressure (psi)
Legend
u2 penetration
Initial dissipation
End of dissipation (extrapolated)
Initial estimated at t=0


Piezocone Dissipation Test: 040RIS-6
Depth: 35.76 (ft)
Porepressure u2 (psi)
assumed initial pore pressure, ui
u initial dissipation
u0 = 15.51 (psi)
25.019
t^0.50 (s^0.50)


Pore pressure
Depth (ft)
Pressure (psi)
Legend
u2 penetration
Initial dissipation
End of dissipation (extrapolated)
Initial estimated at t=0


Piezocone Dissipation Test: 040RIS-6
Depth: 77.43 (ft)
assumed initial pore pressure, ui
u0 = 33.57 (psi)
u initial dissipation
15.926
Porepressure u2 (psi)
t^0.50 (s^0.50)


Pore pressure
Depth (ft)
Pressure (psi)
Legend
u2 penetration
Initial dissipation
End of dissipation (extrapolated)
Initial estimated at t=0

Dissipation Tests Results

Dissipation tests

Dissipation tests consists of stopping the piezocone penetration and observing porepressures (u) with elapsed time (t). The data are automatic recorded by the field computer and should take place until a minimum of 50% dissipation.

The porepressures are plotted as a function of square root of (t). The graphical technique suggested by Robertson and Campanella (1989), yields a value for t_{50}, which corresponds to the time for 50% consolidation.

The value of the coefficient of consolidation in the radial or horizontal direction c_h was then calculated by Houlsby and Teh's (1988) theory using the following equation:

$$c_h = \frac{T \times r^2 \times I_r^{0.5}}{t_{50}}$$

where:

T: time factor given by Houlsby and Teh's (1988) theory corresponding to the porepressure position
r: piezocone radius
I_r: stiffness index, equal to shear modulus G divided by the undrained strength of clay (S_u).
t_{50}: time corresponding to 50% consolidation

Permeability estimates based on dissipation test

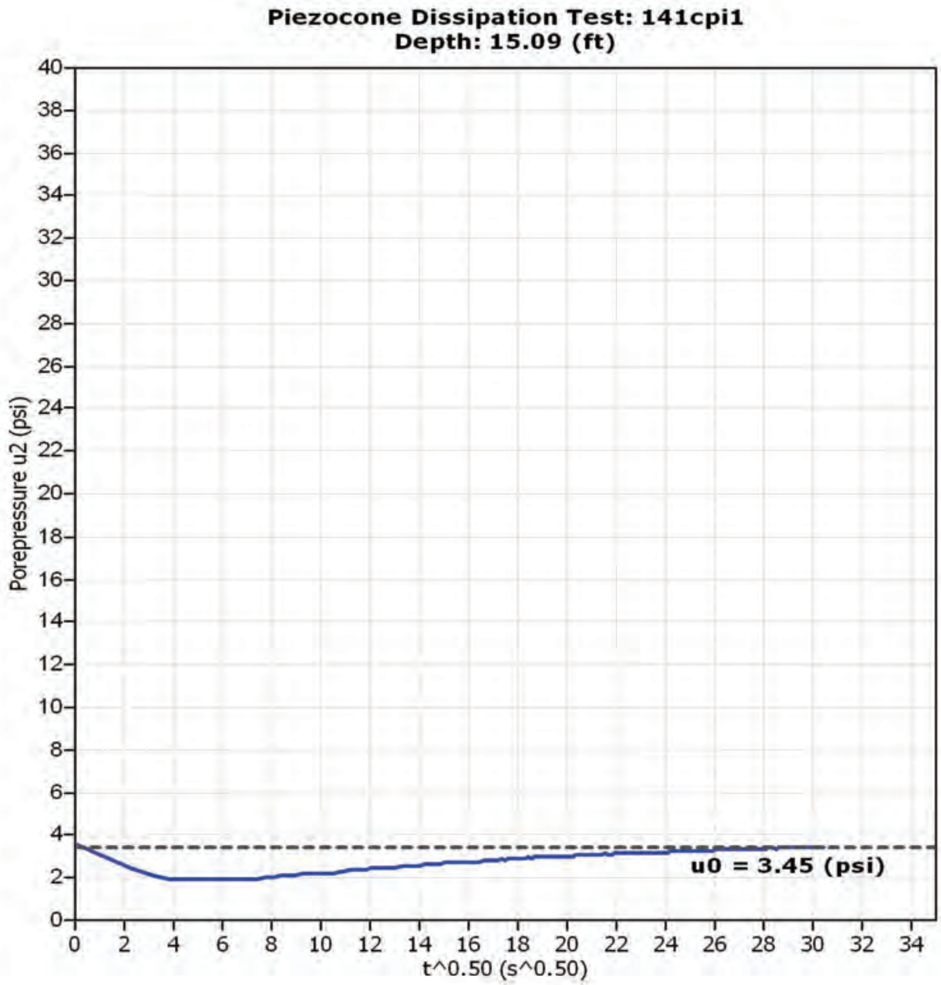
The dissipation of pore pressures during a CPTu dissipation test is controlled by the coefficient of consolidation in the horizontal direction (c_h) which is influenced by a combination of the soil permeability (k_h) and compressibility (M), as defined by the following:

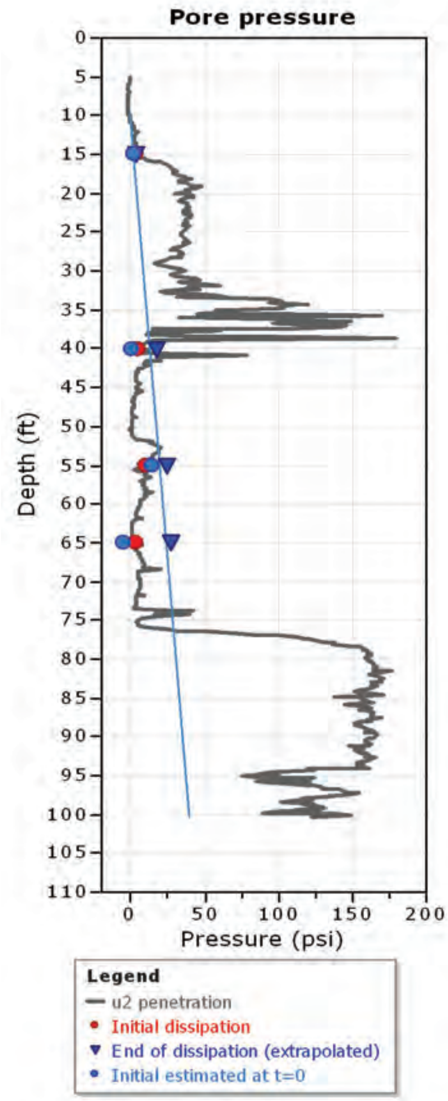
$$k_h = c_h \times \gamma_w / M$$

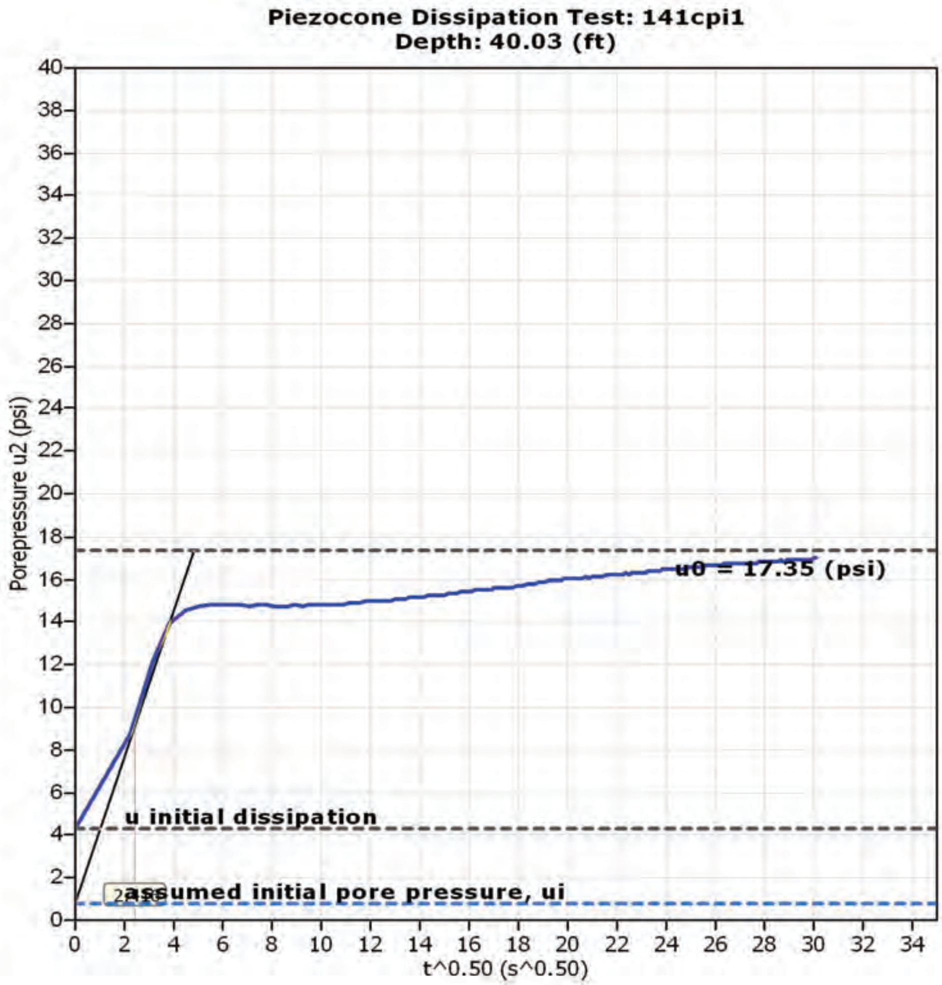
where: M is the 1-D constrained modulus and γ_w is the unit weight of water, in compatible units.

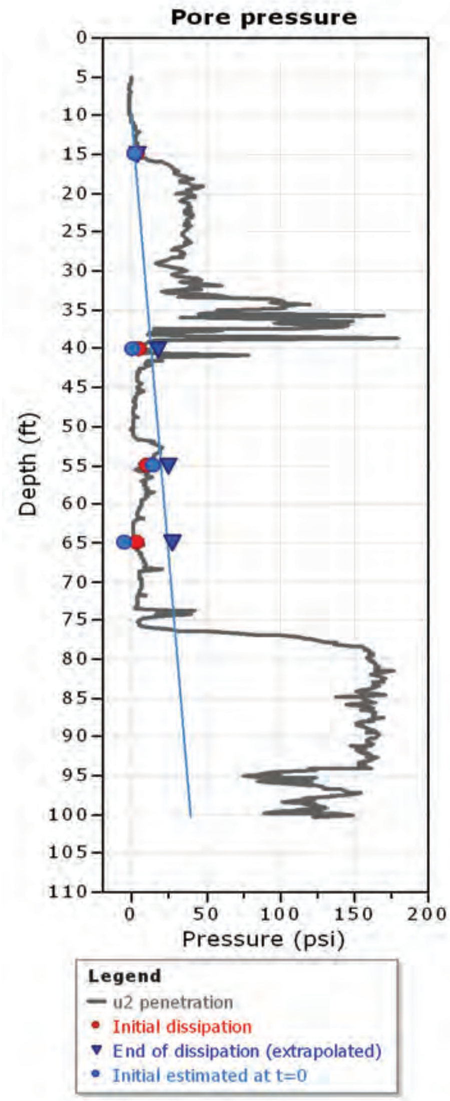
Tabular results

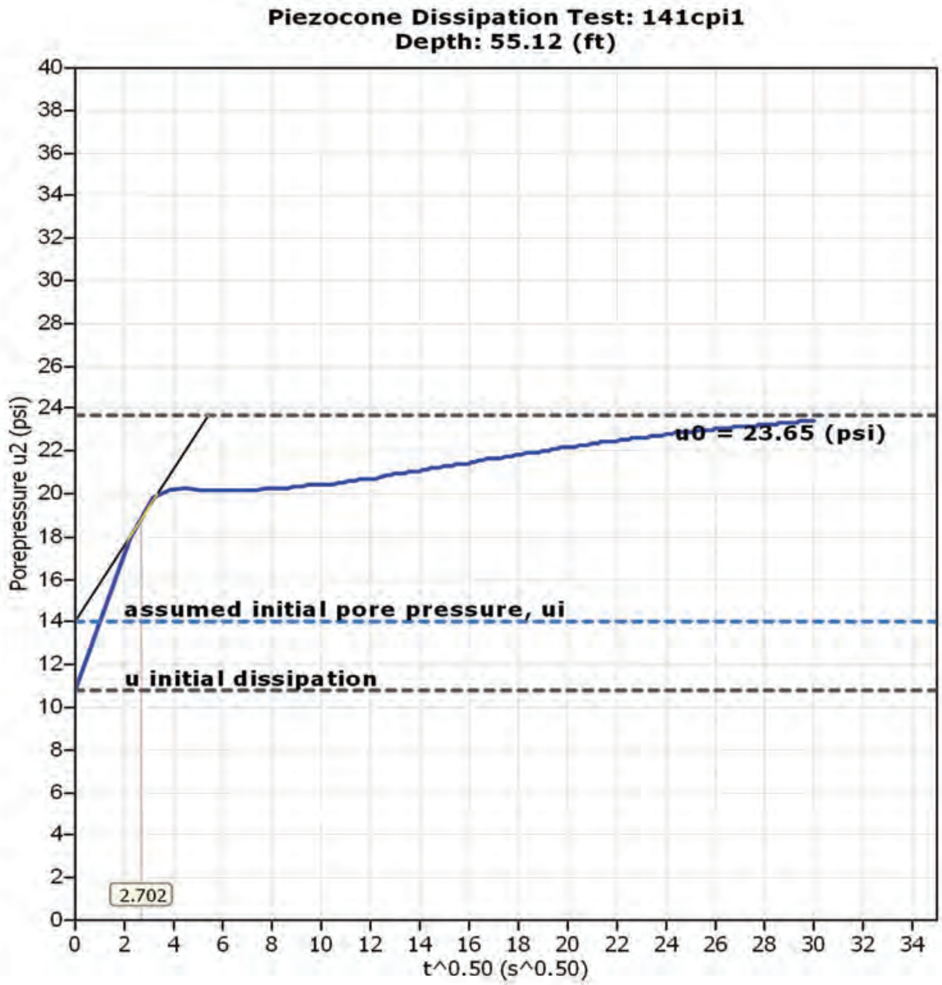
CPTU Borehole	Depth (ft)	$(t_{50})^{0.50}$	t_{50} (s)	t_{50} (years)	G/S_u	c_h (ft^2/s)	c_h ($ft^2/year$)	M (tsf)	k_h (ft/s)
141cpi1	15.09	8.5	72	2.29E-006	500.00	3.94E-004	12425	1000.00	1.23E-008
141cpi1	40.03	2.4	6	1.85E-007	500.00	4.87E-003	153442	1000.00	1.52E-007
141cpi1	55.12	2.7	7	2.31E-007	500.00	3.89E-003	122691	1000.00	1.21E-007
141cpi1	65.12	3.8	15	4.67E-007	500.00	1.93E-003	60793	1000.00	6.02E-008

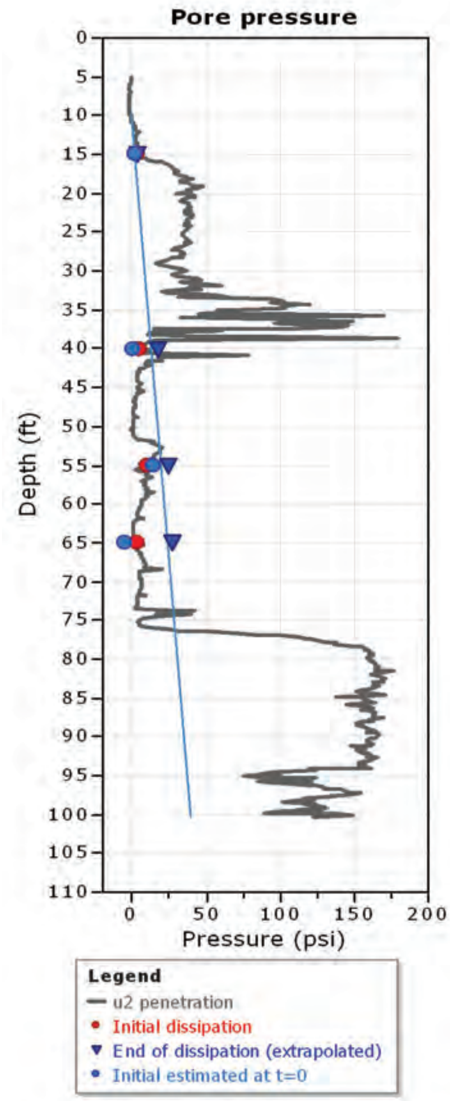

Piezocone Dissipation Test: 141cpi1
Depth: 15.09 (ft)
Porepressure u2 (psi)
t^0.50 (s^0.50)
u0 = 3.45 (psi)

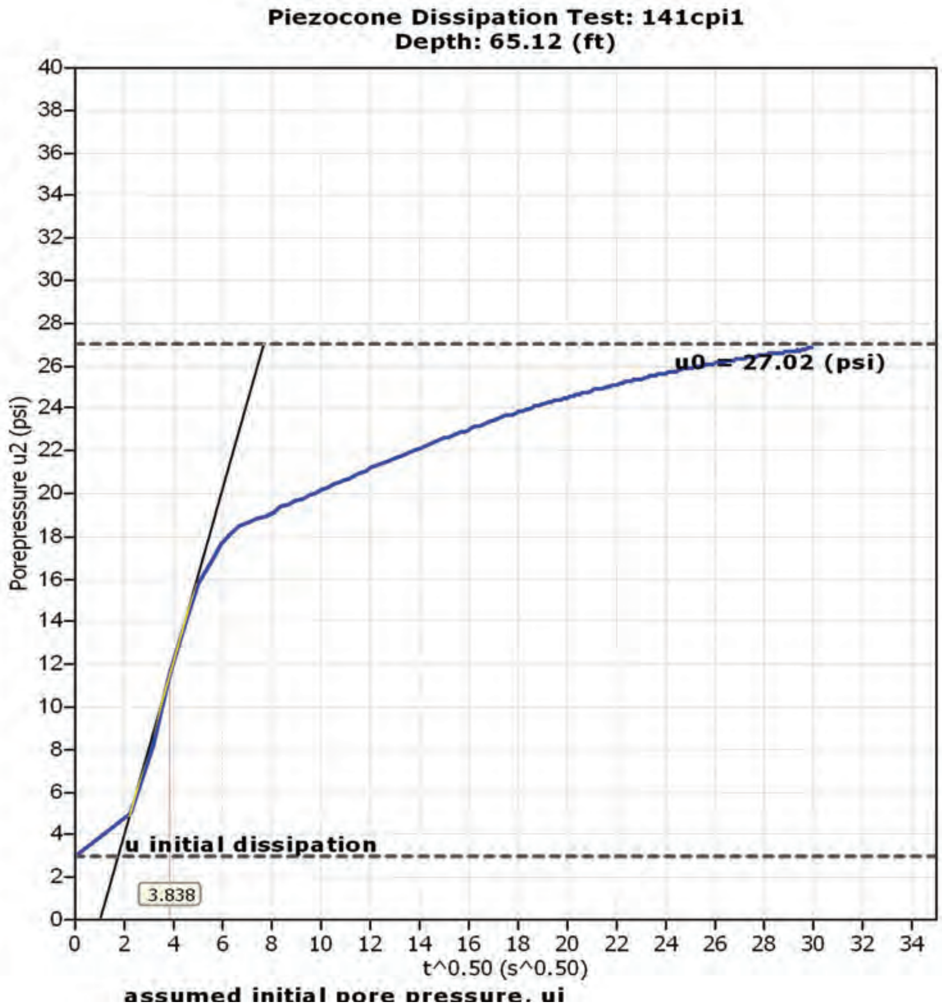

Pore pressure
Depth (ft)
Pressure (psi)
Legend
u2 penetration
Initial dissipation
End of dissipation (extrapolated)
Initial estimated at t=0

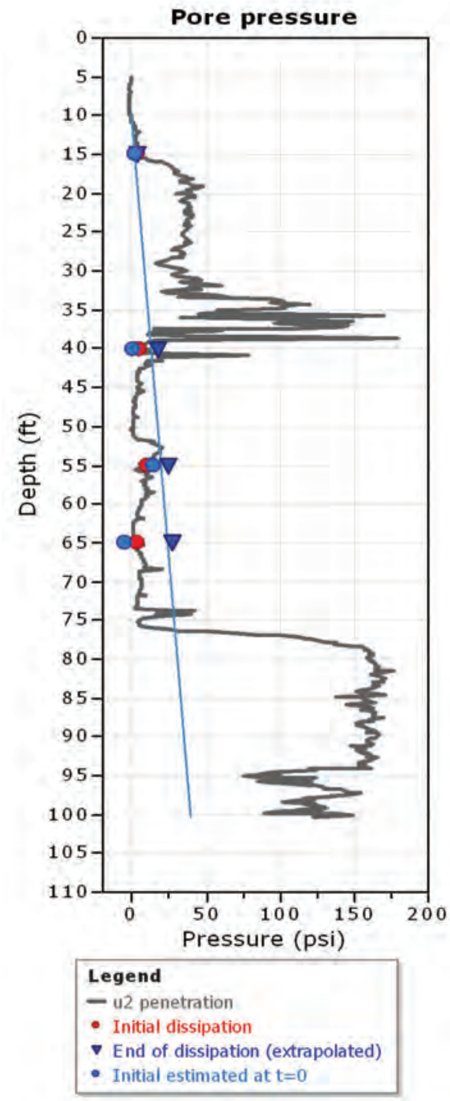

Piezocone Dissipation Test: 141cpi1
Depth: 40.03 (ft)
Porepressure u2 (psi)
t^0.50 (s^0.50)
u0 = 17.35 (psi)
u initial dissipation
assumed initial pore pressure, ui
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40


Pore pressure
Depth (ft)
Pressure (psi)
Legend
u2 penetration
Initial dissipation
End of dissipation (extrapolated)
Initial estimated at t=0


Piezocone Dissipation Test: 141cpi1
Depth: 55.12 (ft)
Porepressure u2 (psi)
t^0.50 (s^0.50)
u0 = 23.65 (psi)
assumed initial pore pressure, ui
u initial dissipation
2.702


Pore pressure
Depth (ft)
Pressure (psi)
Legend
u2 penetration
Initial dissipation
End of dissipation (extrapolated)
Initial estimated at t=0


Piezocone Dissipation Test: 141cpi1
Depth: 65.12 (ft)
Porepressure u2 (psi)
t^0.50 (s^0.50)
u0 = 27.02 (psi)
u initial dissipation
3.838
assumed initial pore pressure, ui
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40


Pore pressure
Depth (ft)
Pressure (psi)
0
50
100
150
200
Legend
u2 penetration
Initial dissipation
End of dissipation (extrapolated)
Initial estimated at t=0

Dissipation Tests Results

Dissipation tests

Dissipation tests consists of stopping the piezocone penetration and observing porepressures (u) with elapsed time (t). The data are automatic recorded by the field computer and should take place until a minimum of 50% dissipation.

The porepressures are plotted as a function of square root of (t). The graphical technique suggested by Robertson and Campanella (1989), yields a value for t_{50}, which corresponds to the time for 50% consolidation.

The value of the coefficient of consolidation in the radial or horizontal direction c_h was then calculated by Houlsby and Teh's (1988) theory using the following equation:

$$c_h = \frac{T \times r^2 \times I_r^{0.5}}{t_{50}}$$

where:

T: time factor given by Houlsby and Teh's (1988) theory corresponding to the porepressure position
r: piezocone radius
I_r: stiffness index, equal to shear modulus G divided by the undrained strength of clay (S_u).
t_{50}: time corresponding to 50% consolidation

Permeability estimates based on dissipation test

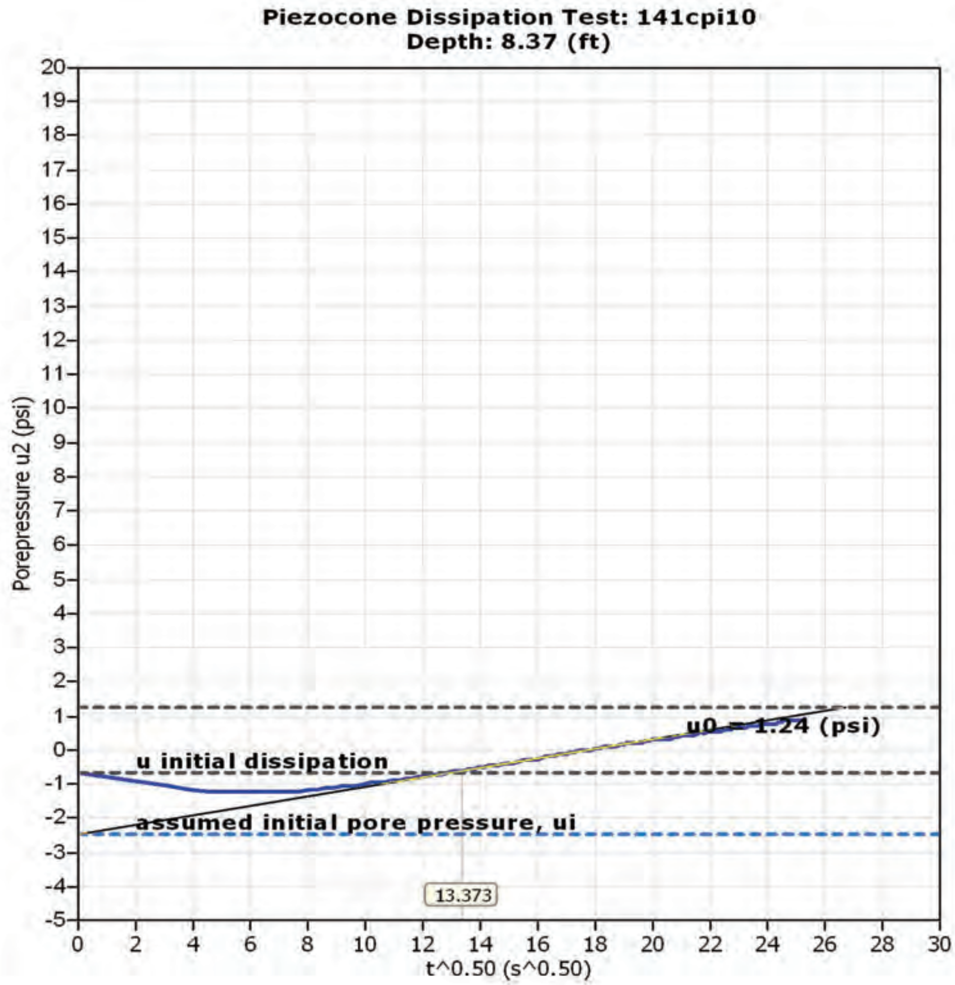
The dissipation of pore pressures during a CPTu dissipation test is controlled by the coefficient of consolidation in the horizontal direction (c_h) which is influenced by a combination of the soil permeability (k_h) and compressibility (M), as defined by the following:

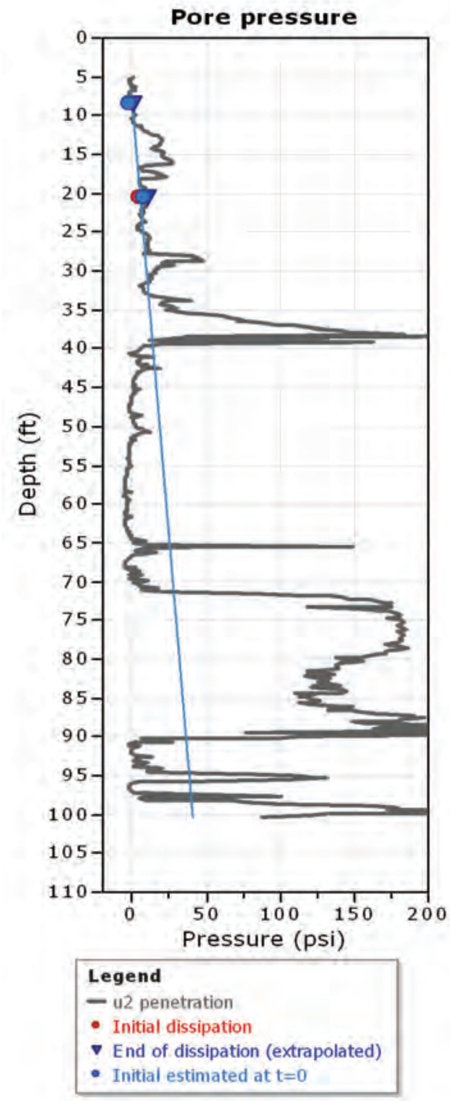
$$k_h = c_h \times \gamma_w / M$$

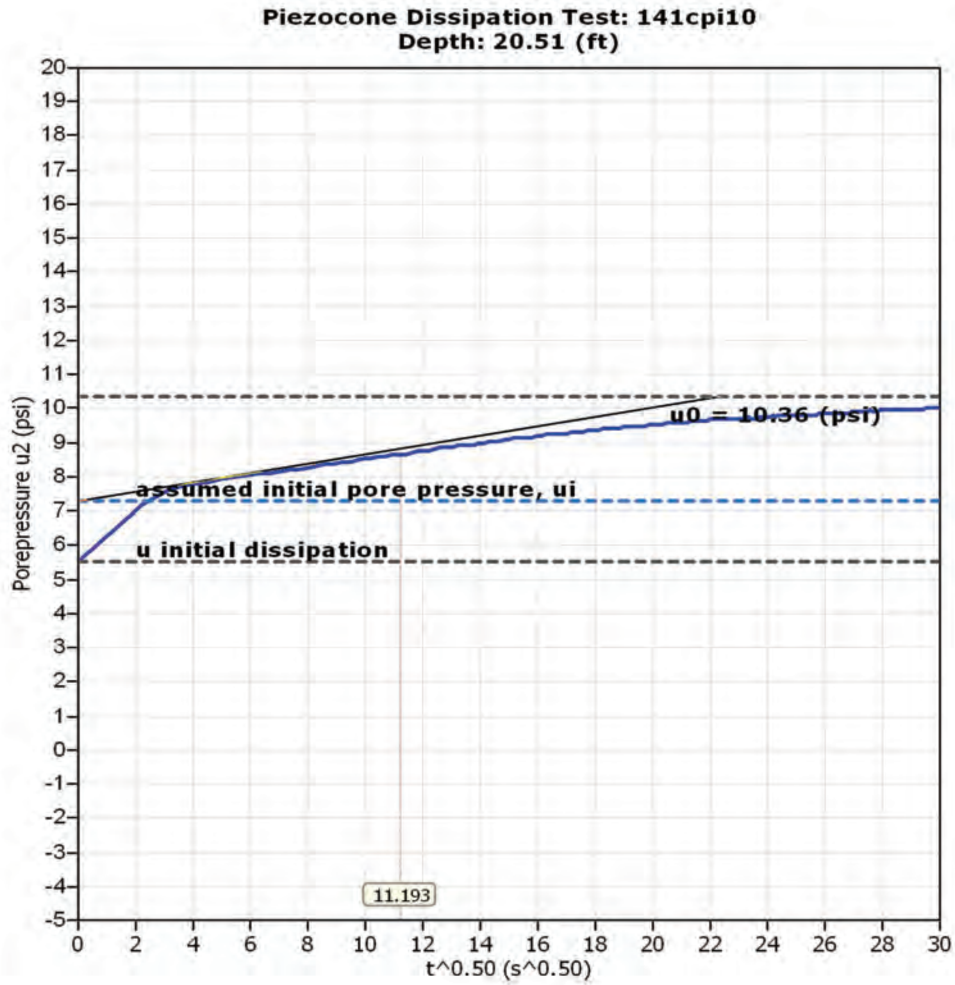
where: M is the 1-D constrained modulus and γ_w is the unit weight of water, in compatible units.

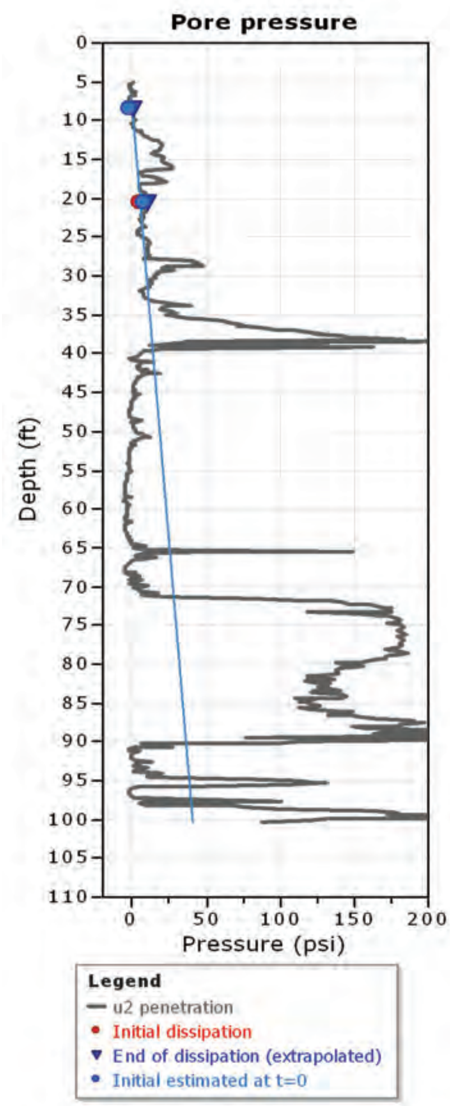
Tabular results

CPTU Borehole	Depth (ft)	$(t_{50})^{0.50}$	t_{50} (s)	t_{50} (years)	G/S_u	c_h (ft^2/s)	c_h ($ft^2/year$)	M (tsf)	k_h (ft/s)
141cpi10	8.37	13.4	179	5.67E-006	500.00	1.59E-004	5008	1000.00	4.96E-009
141cpi10	20.51	11.2	125	3.97E-006	500.00	2.27E-004	7149	1000.00	7.08E-009


Piezocone Dissipation Test: 141cpi10
Depth: 8.37 (ft)
Porepressure u2 (psi)
t^0.50 (s^0.50)
u0 = 1.24 (psi)
u initial dissipation
assumed initial pore pressure, ui
13.373


Pore pressure
Depth (ft)
Pressure (psi)
Legend
u2 penetration
Initial dissipation
End of dissipation (extrapolated)
Initial estimated at t=0


Piezocone Dissipation Test: 141cpi10
Depth: 20.51 (ft)
Porepressure u2 (psi)
t^0.50 (s^0.50)
u0 = 10.36 (psi)
assumed initial pore pressure, ui
u initial dissipation
11.193


Pore pressure
Depth (ft)
Pressure (psi)
Legend
u2 penetration
Initial dissipation
End of dissipation (extrapolated)
Initial estimated at t=0

Dissipation Tests Results

Dissipation tests

Dissipation tests consists of stopping the piezocone penetration and observing porepressures (u) with elapsed time (t). The data are automatic recorded by the field computer and should take place until a minimum of 50% dissipation.

The porepressures are plotted as a function of square root of (t). The graphical technique suggested by Robertson and Campanella (1989), yields a value for t_{50}, which corresponds to the time for 50% consolidation.

The value of the coefficient of consolidation in the radial or horizontal direction c_h was then calculated by Houlsby and Teh's (1988) theory using the following equation:

$$c_h = \frac{T \times r^2 \times I_r^{0.5}}{t_{50}}$$

where:

T: time factor given by Houlsby and Teh's (1988) theory corresponding to the porepressure position
r: piezocone radius
I_r: stiffness index, equal to shear modulus G divided by the undrained strength of clay (S_u).
t_{50}: time corresponding to 50% consolidation

Permeability estimates based on dissipation test

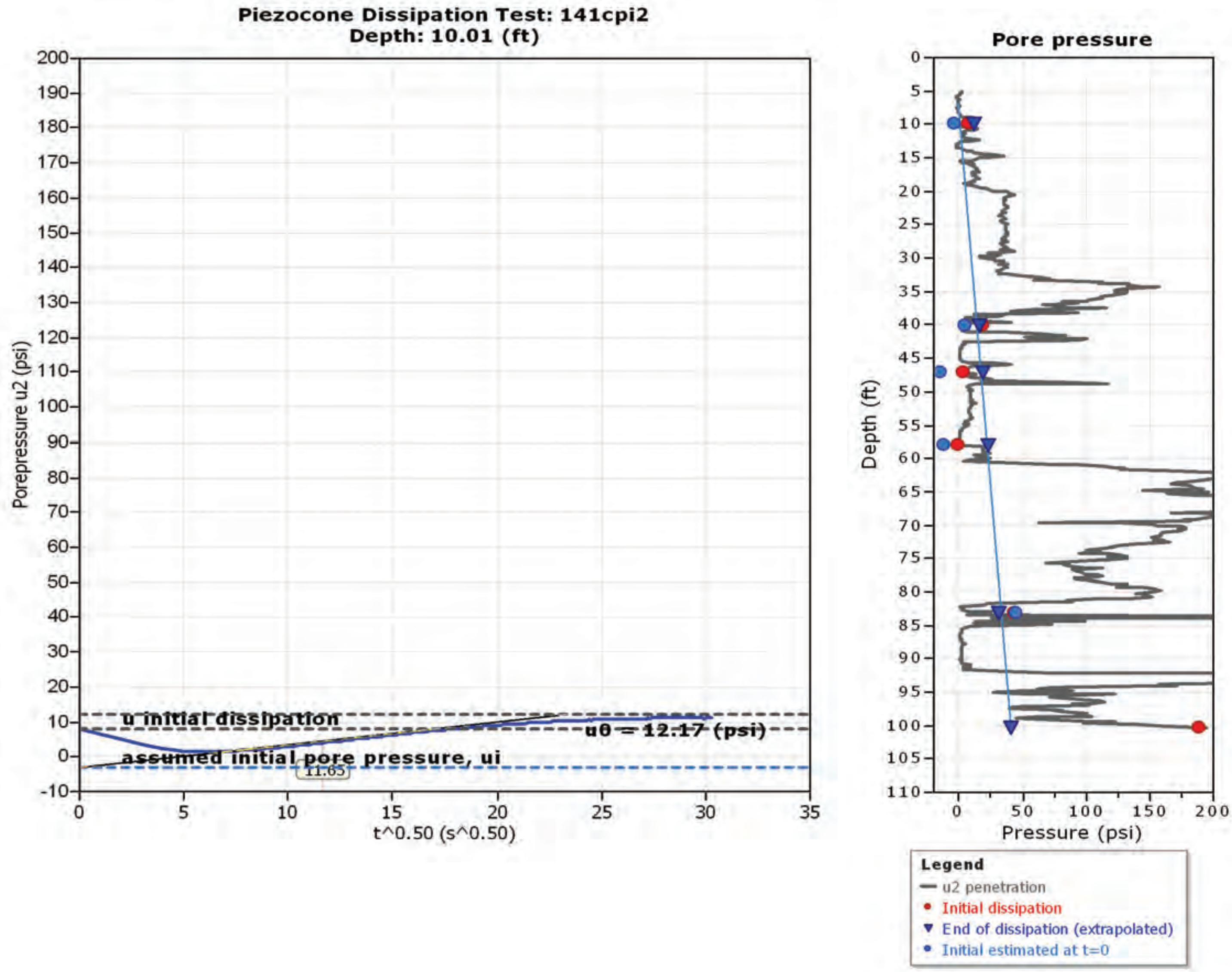
The dissipation of pore pressures during a CPTu dissipation test is controlled by the coefficient of consolidation in the horizontal direction (c_h) which is influenced by a combination of the soil permeability (k_h) and compressibility (M), as defined by the following:

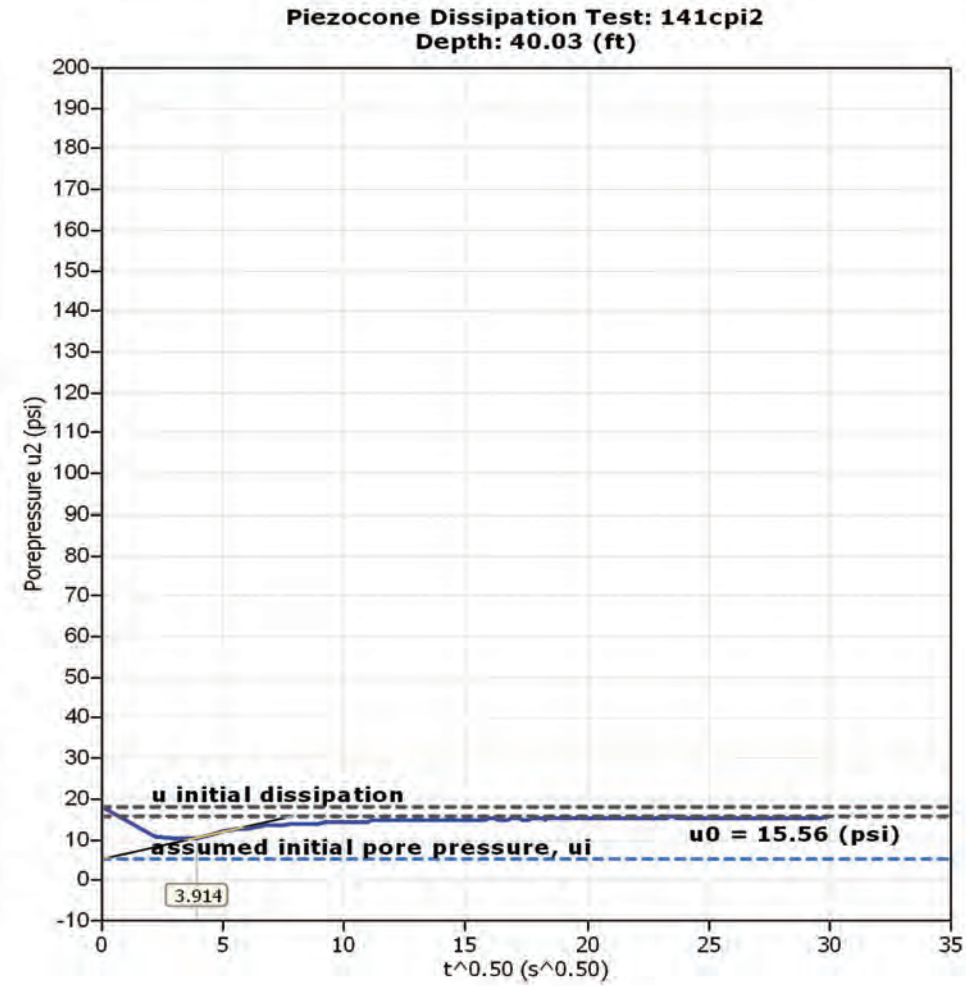
$$k_h = c_h \times \gamma_w / M$$

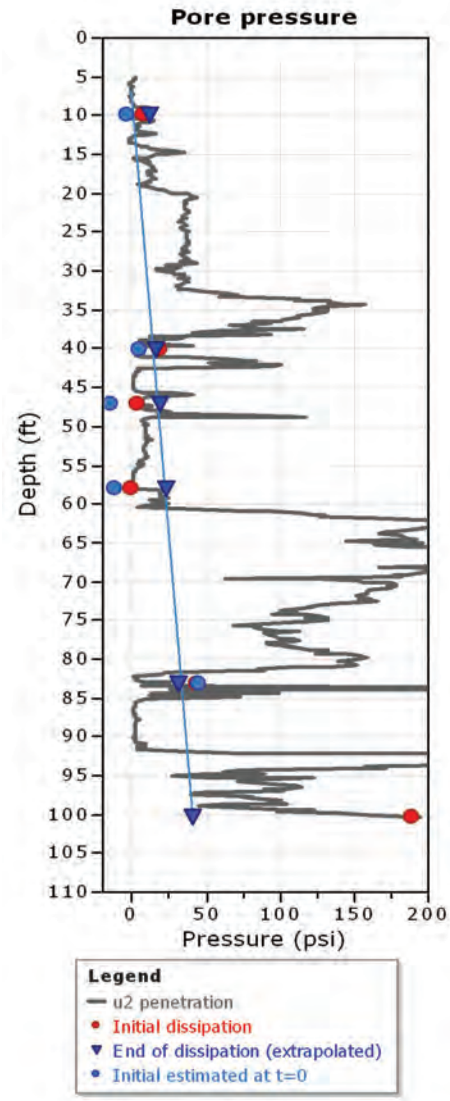
where: M is the 1-D constrained modulus and γ_w is the unit weight of water, in compatible units.

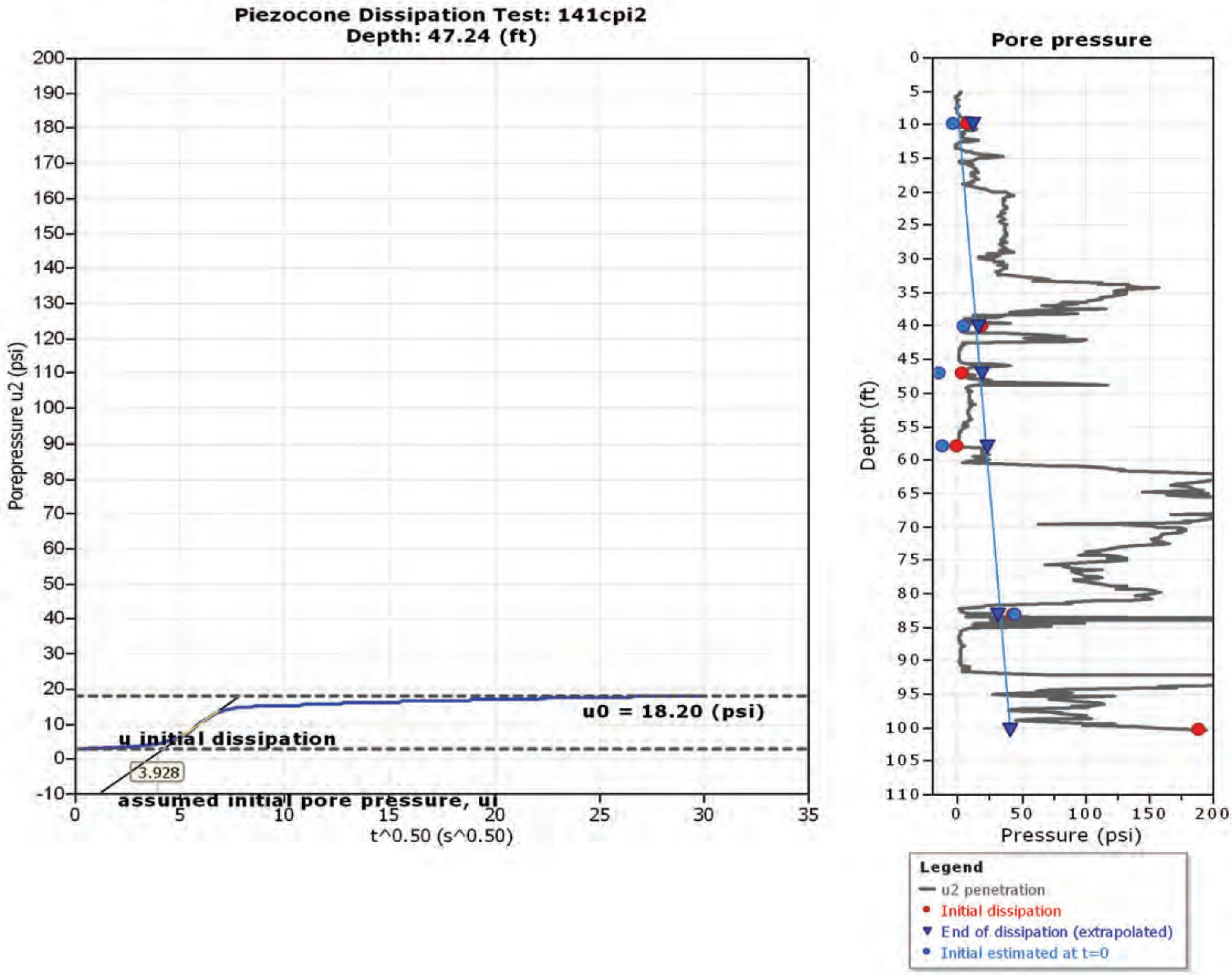
Tabular results

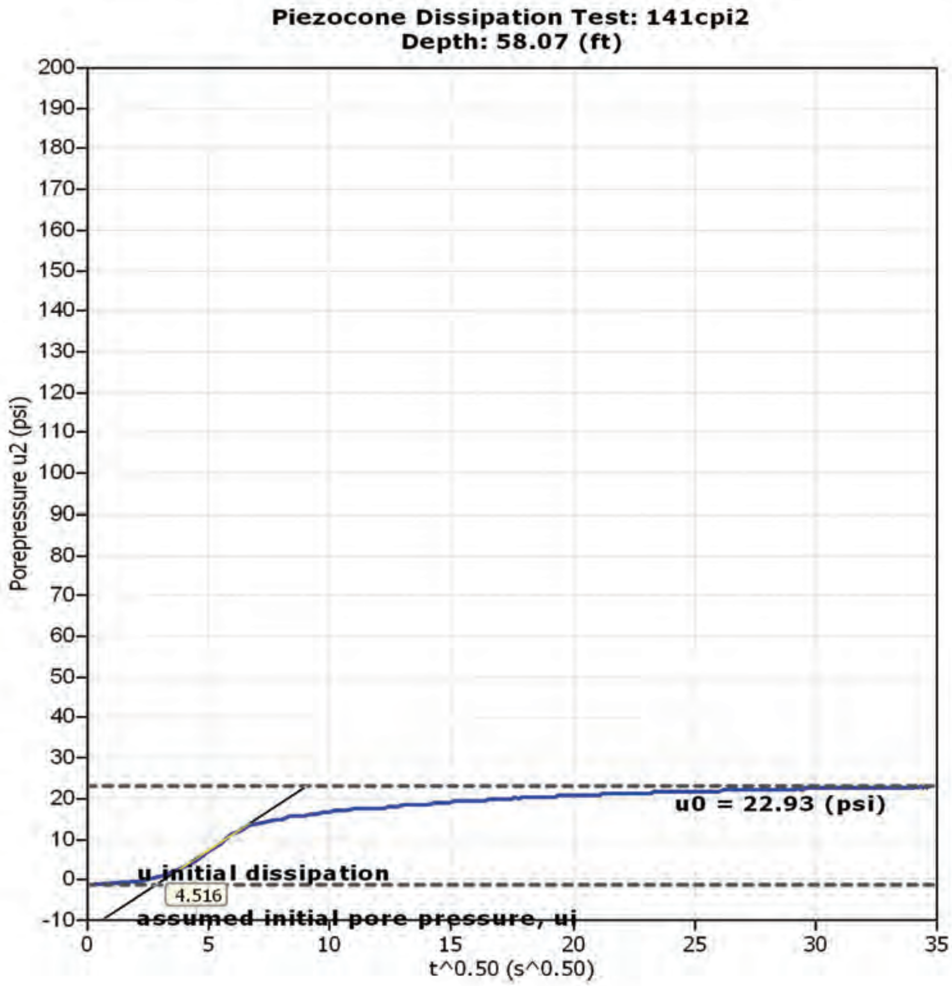
CPTU Borehole	Depth (ft)	$(t_{50})^{0.50}$	t_{50} (s)	t_{50} (years)	G/S_u	c_h (ft^2/s)	c_h ($ft^2/year$)	M (tsf)	k_h (ft/s)
141cpi2	10.01	11.7	136	4.30E-006	500.00	2.09E-004	6599	1000.00	6.53E-009
141cpi2	40.03	3.9	15	4.86E-007	500.00	1.85E-003	58449	1000.00	5.79E-008
141cpi2	47.24	3.9	15	4.89E-007	500.00	1.84E-003	58062	1000.00	5.75E-008
141cpi2	58.07	4.5	20	6.47E-007	500.00	1.39E-003	43923	1000.00	4.35E-008
141cpi2	83.17	2.4	6	1.80E-007	500.00	5.00E-003	157790	1000.00	1.56E-007
141cpi2	100.23	9.2	84	2.66E-006	500.00	3.38E-004	10658	1000.00	1.06E-008


Piezocone Dissipation Test: 141cpi2
Depth: 10.01 (ft)
Porepressure u2 (psi)
t^0.50 (s^0.50)
u initial dissipation
u0 = 12.17 (psi)
assumed initial pore pressure, ui
11.65
Pore pressure
Depth (ft)
Pressure (psi)
Legend
u2 penetration
Initial dissipation
End of dissipation (extrapolated)
Initial estimated at t=0

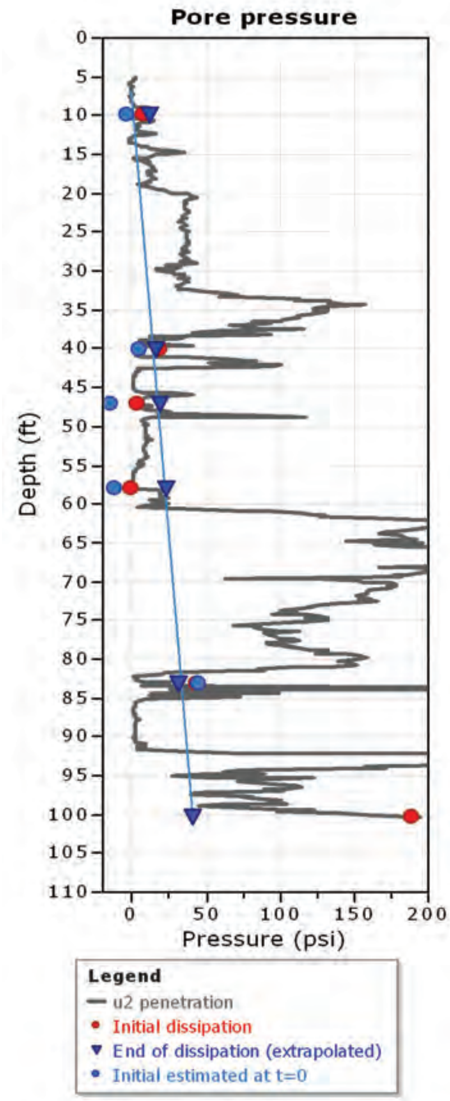

Piezocone Dissipation Test: 141cpi2
Depth: 40.03 (ft)
Porepressure u2 (psi)
t^0.50 (s^0.50)
u initial dissipation
assumed initial pore pressure, ui
u0 = 15.56 (psi)
3.914


Pore pressure
Depth (ft)
Pressure (psi)
Legend
u2 penetration
Initial dissipation
End of dissipation (extrapolated)
Initial estimated at t=0

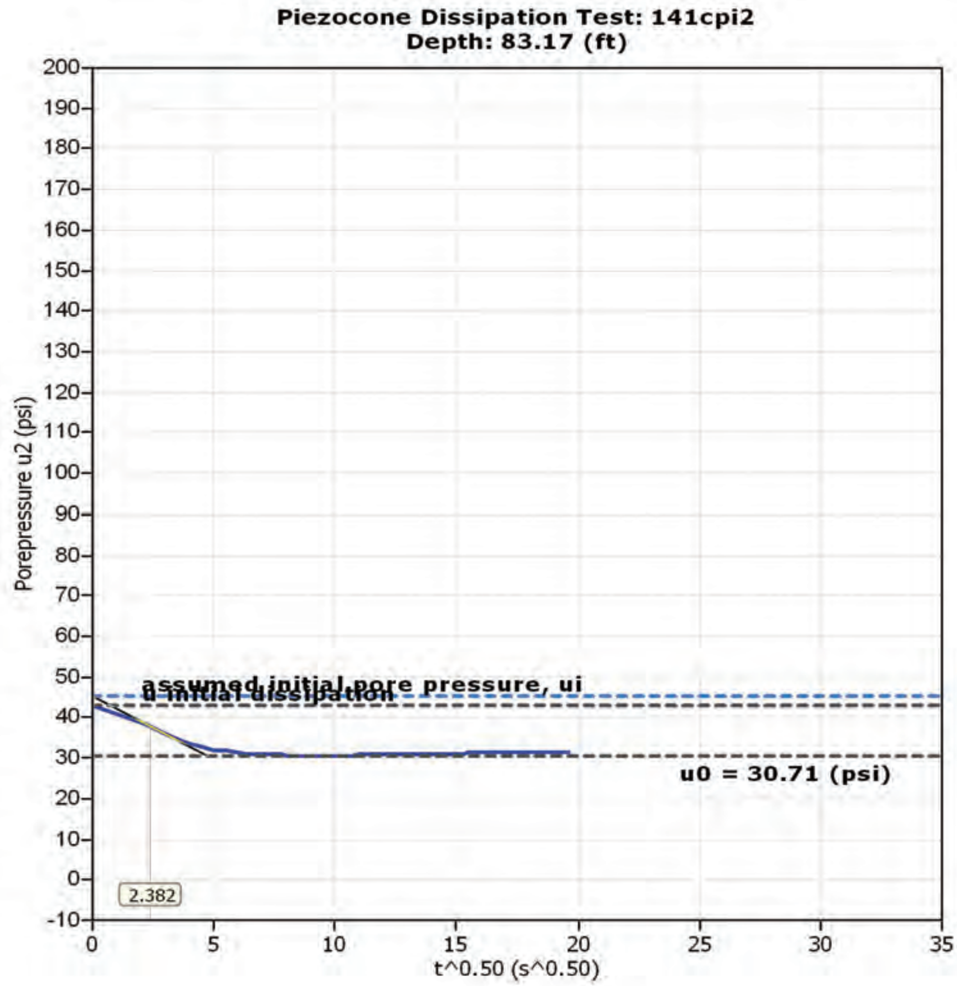

Piezocone Dissipation Test: 141cpi2
Depth: 47.24 (ft)
Porepressure u2 (psi)
t^0.50 (s^0.50)
u0 = 18.20 (psi)
u initial dissipation
3.928
assumed initial pore pressure, ui
Pore pressure
Depth (ft)
Pressure (psi)
Legend
u2 penetration
Initial dissipation
End of dissipation (extrapolated)
Initial estimated at t=0

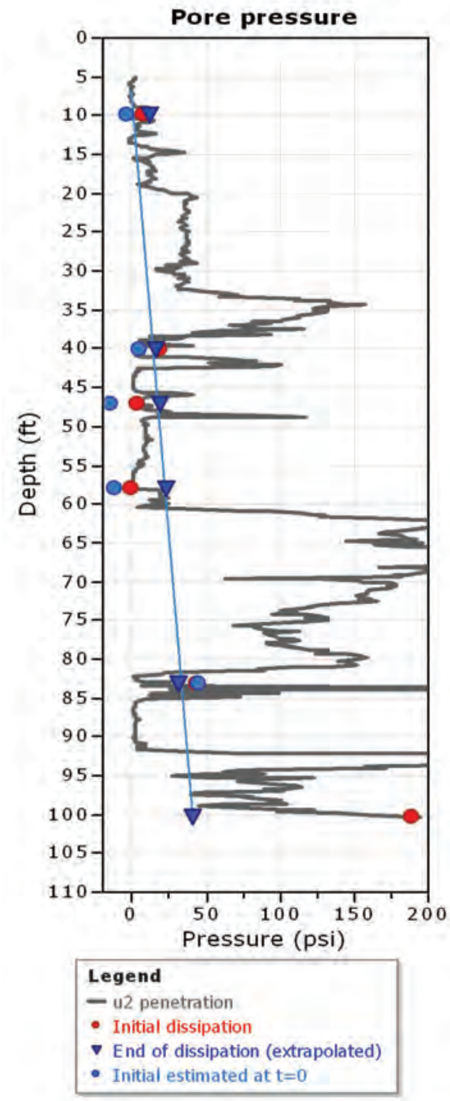


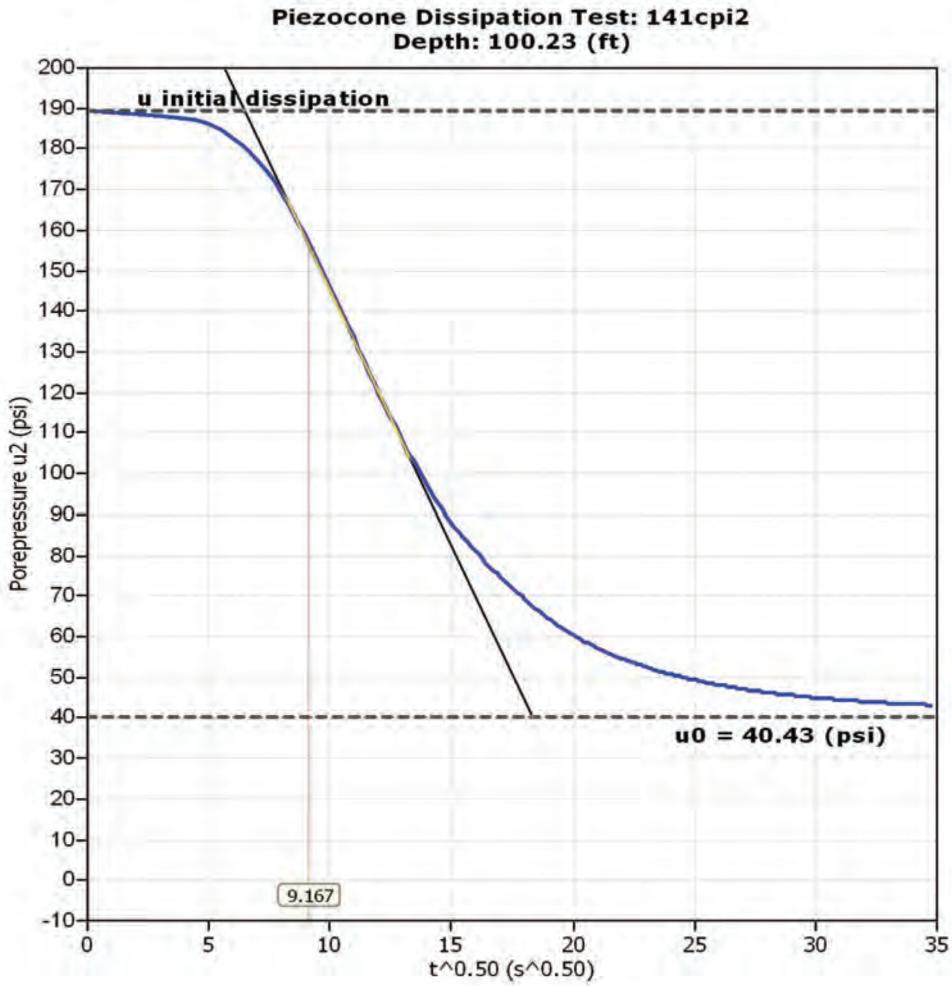
Piezocone Dissipation Test: 141cpi2
Depth: 58.07 (ft)
Porepressure u2 (psi)
t^0.50 (s^0.50)
u0 = 22.93 (psi)
u initial dissipation
4.516
assumed initial pore pressure, ui

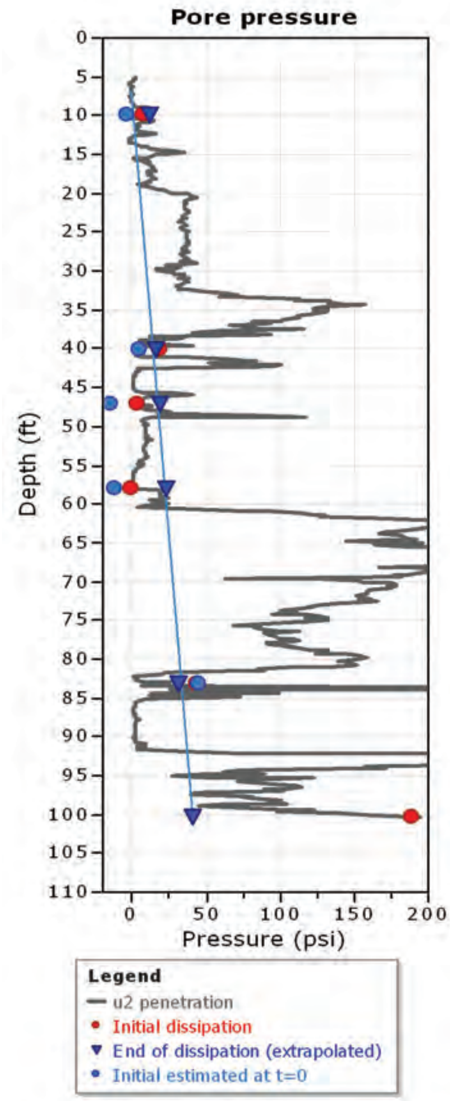


Pore pressure
Depth (ft)
Pressure (psi)
Legend
u2 penetration
Initial dissipation
End of dissipation (extrapolated)
Initial estimated at t=0


Piezocone Dissipation Test: 141cpi2
Depth: 83.17 (ft)
Porepressure u2 (psi)
t^0.50 (s^0.50)
assumed initial pore pressure, ui
u initial dissipation
u0 = 30.71 (psi)
2.382


Pore pressure
Depth (ft)
Pressure (psi)
Legend
u2 penetration
Initial dissipation
End of dissipation (extrapolated)
Initial estimated at t=0


Piezocone Dissipation Test: 141cpi2
Depth: 100.23 (ft)
u initial dissipation
u0 = 40.43 (psi)
9.167
Porepressure u2 (psi)
t^0.50 (s^0.50)


Pore pressure
Depth (ft)
Pressure (psi)
Legend
u2 penetration
Initial dissipation
End of dissipation (extrapolated)
Initial estimated at t=0

Dissipation Tests Results

Dissipation tests

Dissipation tests consists of stopping the piezocone penetration and observing porepressures (u) with elapsed time (t). The data are automatic recorded by the field computer and should take place until a minimum of 50% dissipation.

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$$c_h = \frac{T \times r^2 \times I_r^{0.5}}{t_{50}}$$

where:

T: time factor given by Houlsby and Teh's (1988) theory corresponding to the porepressure position
r: piezocone radius
I_r: stiffness index, equal to shear modulus G divided by the undrained strength of clay (S_u).
t_{50}: time corresponding to 50% consolidation

Permeability estimates based on dissipation test

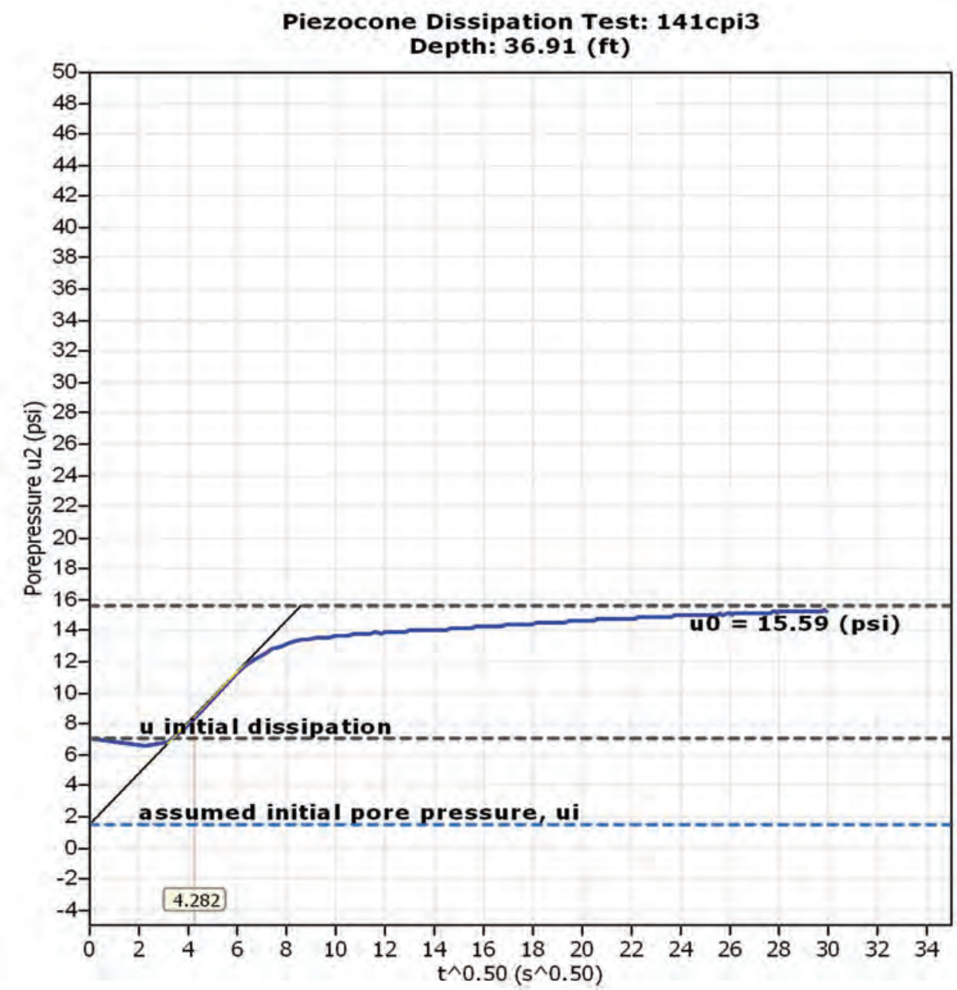
The dissipation of pore pressures during a CPTu dissipation test is controlled by the coefficient of consolidation in the horizontal direction (c_h) which is influenced by a combination of the soil permeability (k_h) and compressibility (M), as defined by the following:

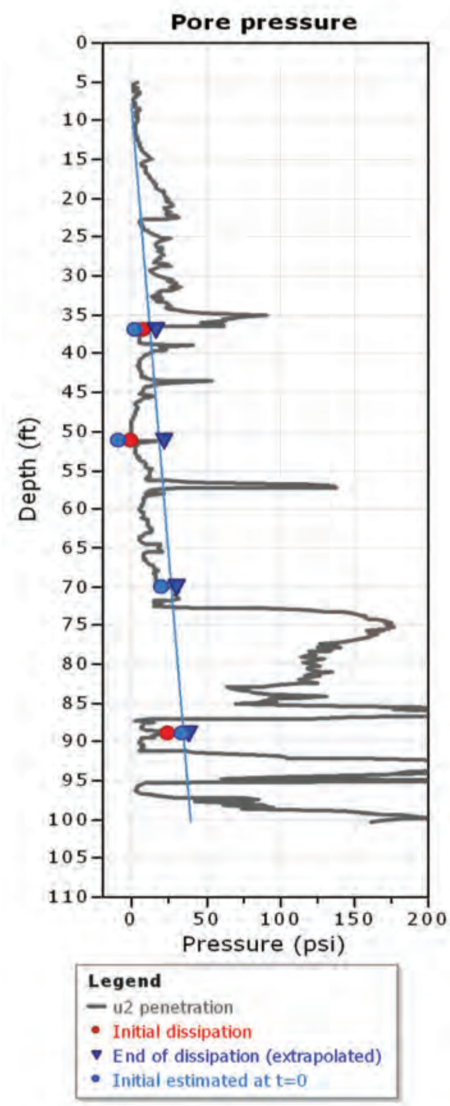
$$k_h = c_h \times \gamma_w / M$$

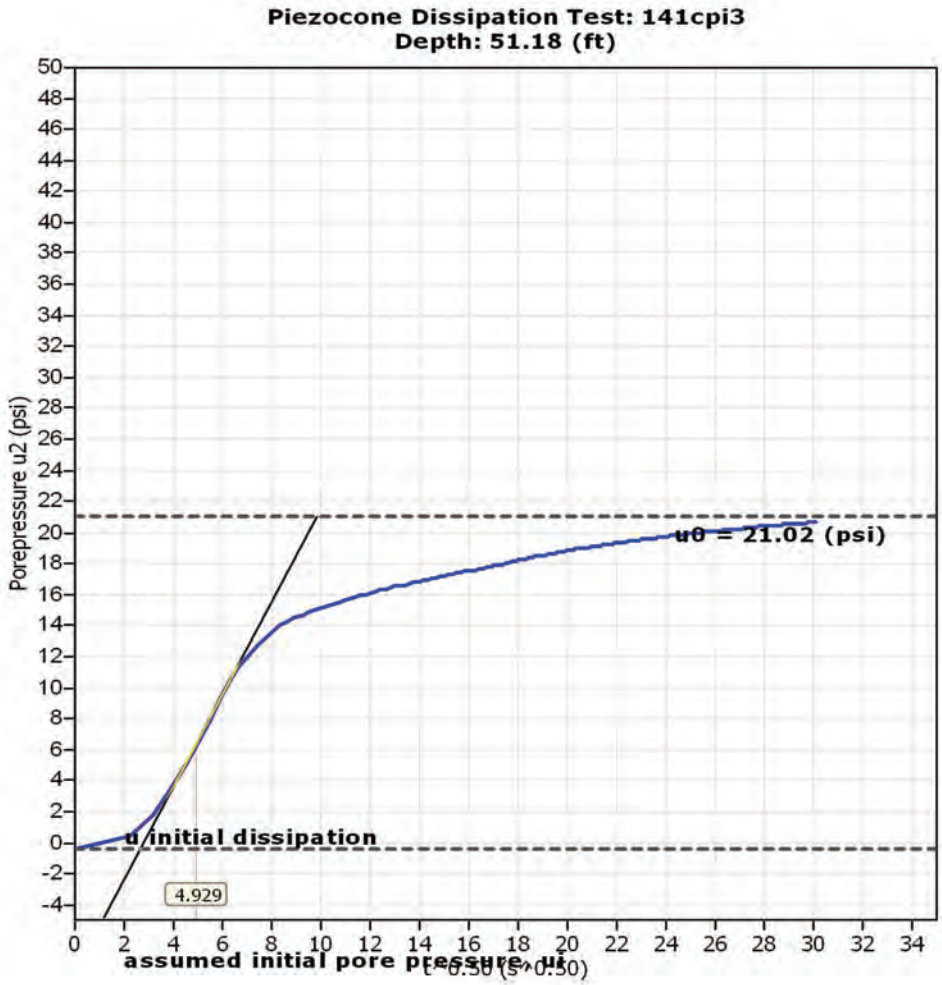
where: M is the 1-D constrained modulus and γ_w is the unit weight of water, in compatible units.

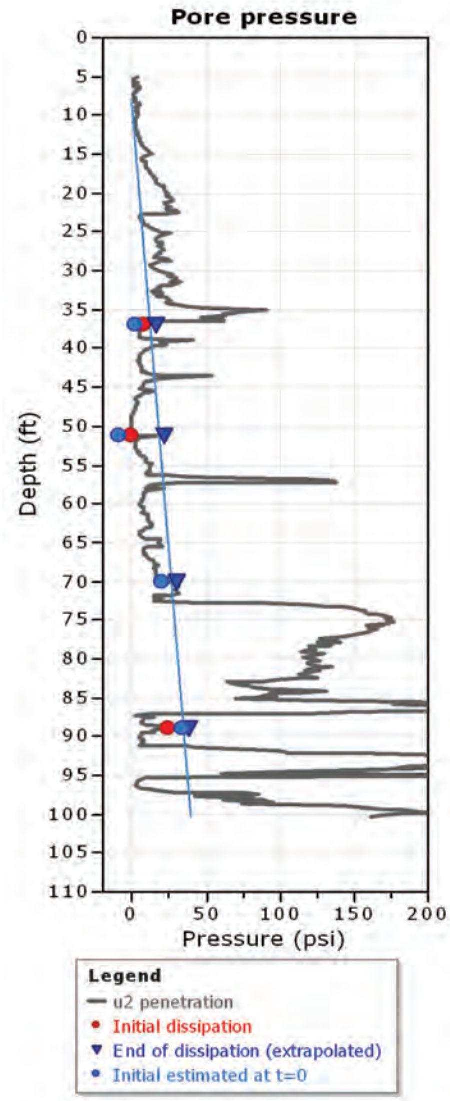
Tabular results

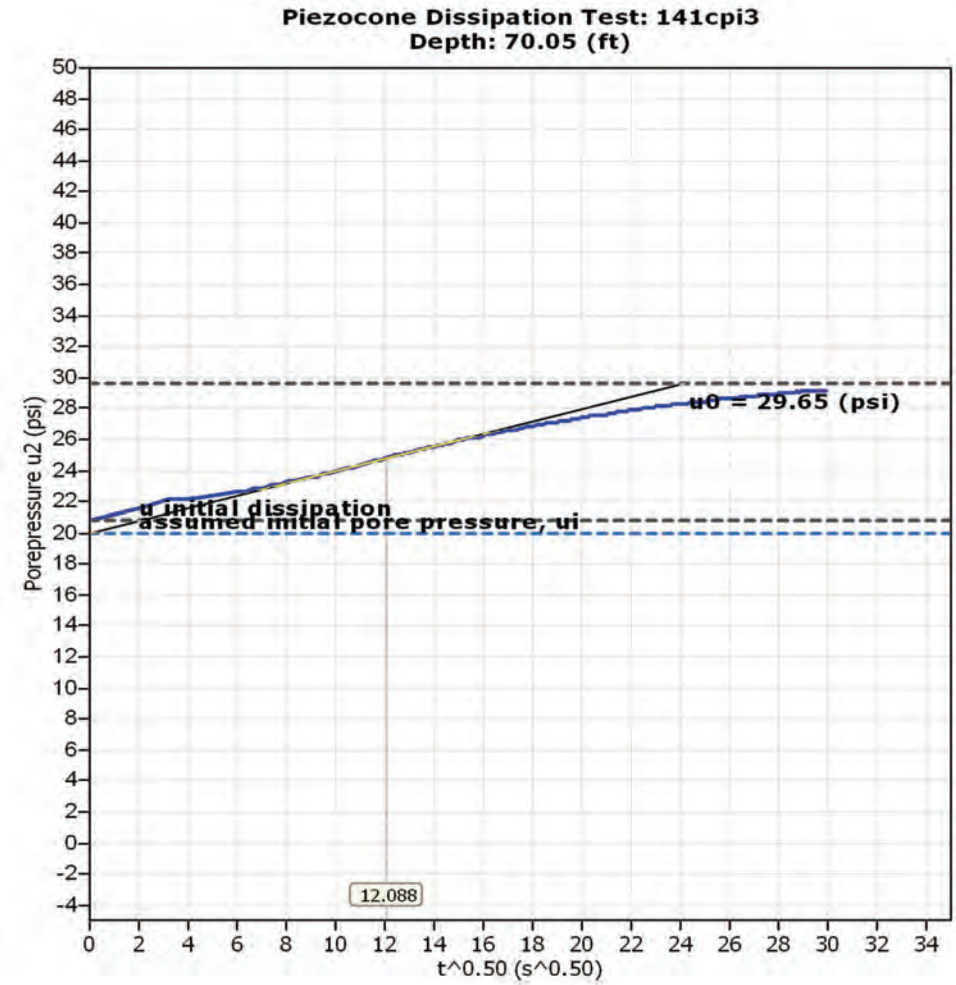
CPTU Borehole	Depth (ft)	$(t_{50})^{0.50}$	t_{50} (s)	t_{50} (years)	G/S_u	c_h (ft^2/s)	c_h ($ft^2/year$)	M (tsf)	k_h (ft/s)
141cpi3	36.91	4.3	18	5.82E-007	500.00	1.55E-003	48838	1000.00	4.83E-008
141cpi3	51.18	4.9	24	7.71E-007	500.00	1.17E-003	36858	1000.00	3.65E-008
141cpi3	70.05	12.1	146	4.63E-006	500.00	1.94E-004	6129	1000.00	6.07E-009
141cpi3	88.91	15.4	237	7.52E-006	500.00	1.20E-004	3775	1000.00	3.74E-009


Piezocone Dissipation Test: 141cpi3
Depth: 36.91 (ft)
Porepressure u2 (psi)
t^0.50 (s^0.50)
u0 = 15.59 (psi)
u initial dissipation
assumed initial pore pressure, ui
4.282

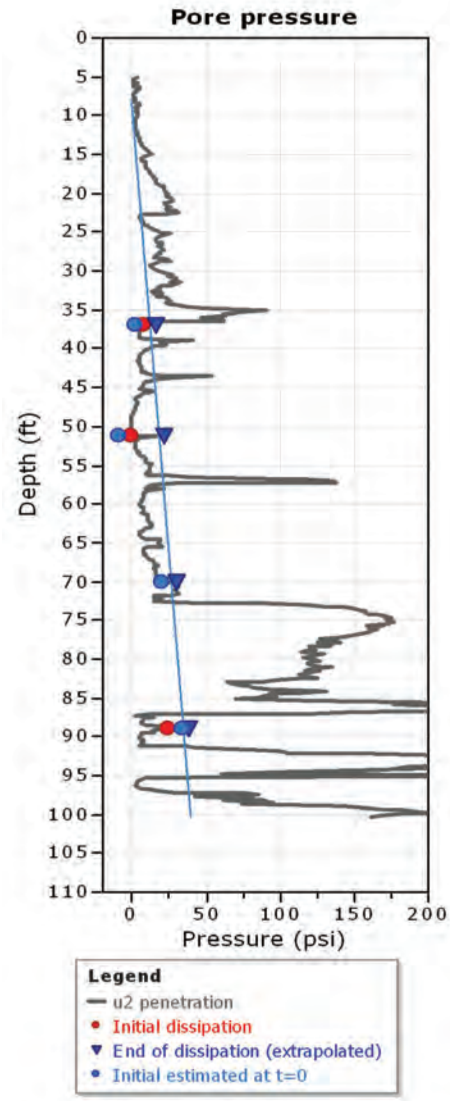

Pore pressure
Depth (ft)
Pressure (psi)
Legend
u2 penetration
Initial dissipation
End of dissipation (extrapolated)
Initial estimated at t=0


Piezocone Dissipation Test: 141cpi3
Depth: 51.18 (ft)
Porepressure u2 (psi)
u0 = 21.02 (psi)
u initial dissipation
4.929
assumed initial pore pressure, ui
t^0.50 (s^0.50)

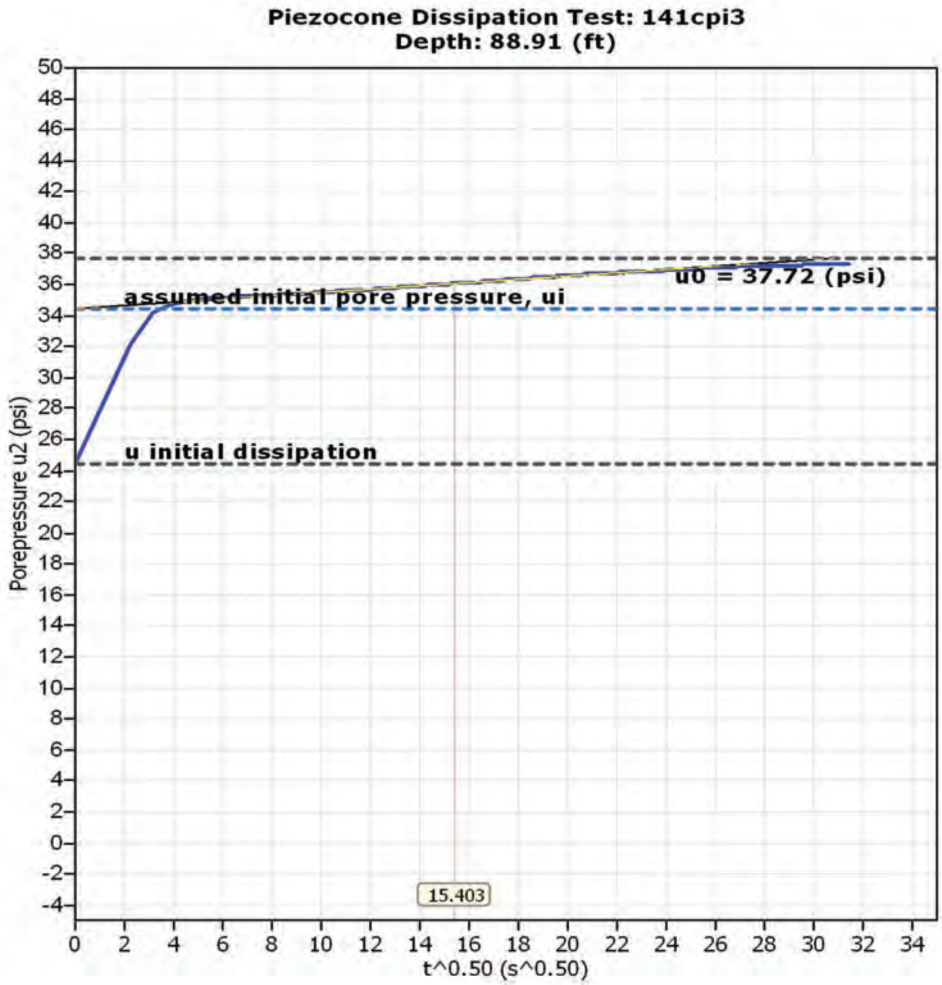

Pore pressure
Depth (ft)
Pressure (psi)
Legend
u2 penetration
Initial dissipation
End of dissipation (extrapolated)
Initial estimated at t=0

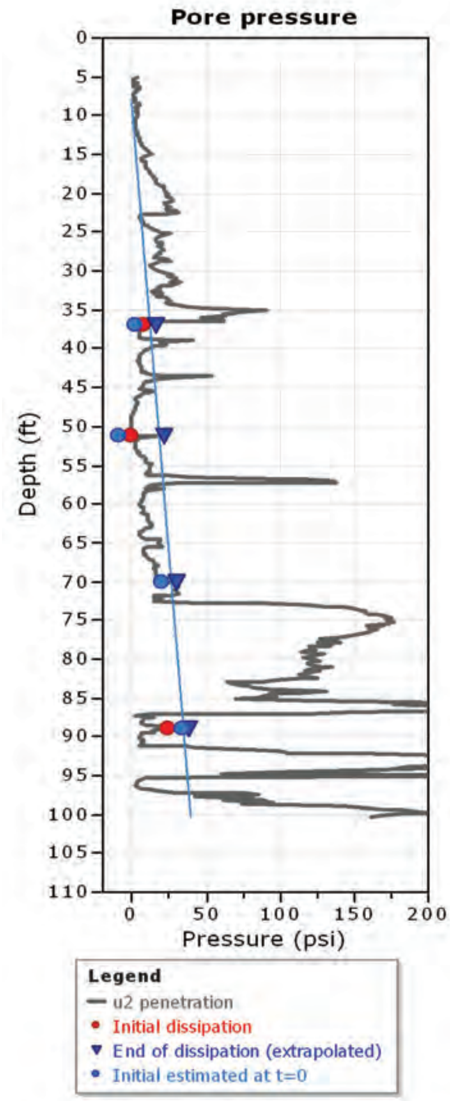


Piezocone Dissipation Test: 141cpi3
Depth: 70.05 (ft)
u0 = 29.65 (psi)
u initial dissipation
assumed initial pore pressure, ui
12.088
Porepressure u2 (psi)
t^0.50 (s^0.50)



Pore pressure
Depth (ft)
Pressure (psi)
Legend
u2 penetration
Initial dissipation
End of dissipation (extrapolated)
Initial estimated at t=0


Piezocone Dissipation Test: 141cpi3
Depth: 88.91 (ft)
u0 = 37.72 (psi)
assumed initial pore pressure, ui
u initial dissipation
Porepressure u2 (psi)
t^0.50 (s^0.50)
15.403


Pore pressure
Depth (ft)
Pressure (psi)
Legend
u2 penetration
Initial dissipation
End of dissipation (extrapolated)
Initial estimated at t=0

Dissipation Tests Results

Dissipation tests

Dissipation tests consists of stopping the piezocone penetration and observing porepressures (u) with elapsed time (t). The data are automatic recorded by the field computer and should take place until a minimum of 50% dissipation.

The porepressures are plotted as a function of square root of (t). The graphical technique suggested by Robertson and Campanella (1989), yields a value for t_{50}, which corresponds to the time for 50% consolidation.

The value of the coefficient of consolidation in the radial or horizontal direction c_h was then calculated by Houlsby and Teh's (1988) theory using the following equation:

$$c_h = \frac{T \times r^2 \times I_r^{0.5}}{t_{50}}$$

where:

T: time factor given by Houlsby and Teh's (1988) theory corresponding to the porepressure position
r: piezocone radius
I_r: stiffness index, equal to shear modulus G divided by the undrained strength of clay (S_u).
t_{50}: time corresponding to 50% consolidation

Permeability estimates based on dissipation test

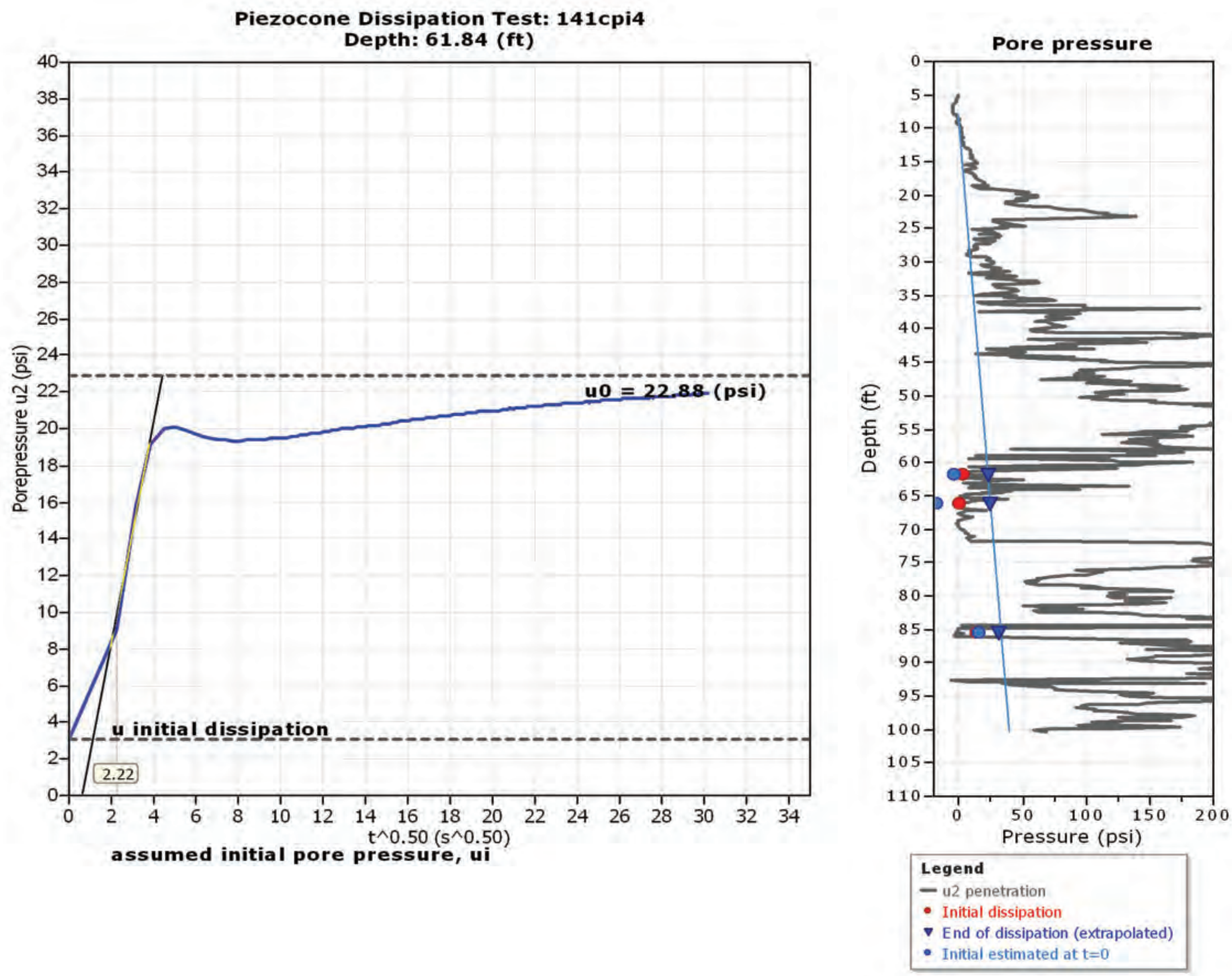
The dissipation of pore pressures during a CPTu dissipation test is controlled by the coefficient of consolidation in the horizontal direction (c_h) which is influenced by a combination of the soil permeability (k_h) and compressibility (M), as defined by the following:

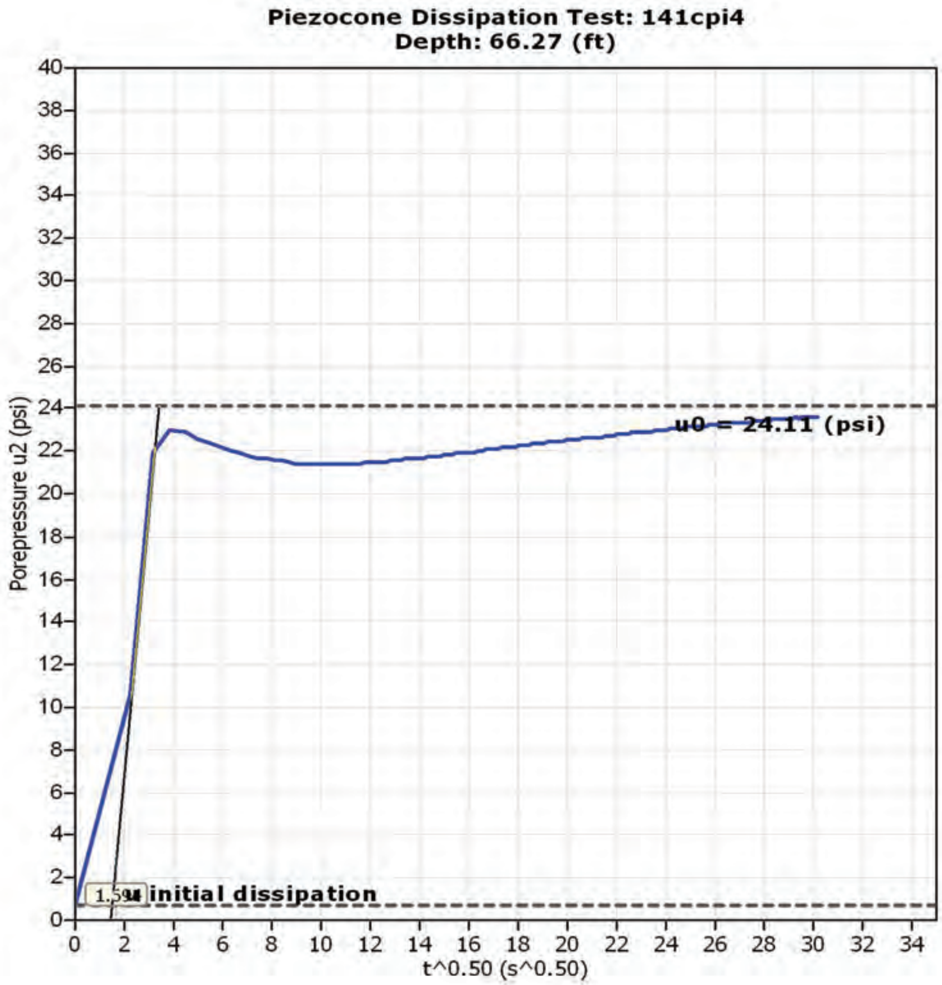
$$k_h = c_h \times \gamma_w / M$$

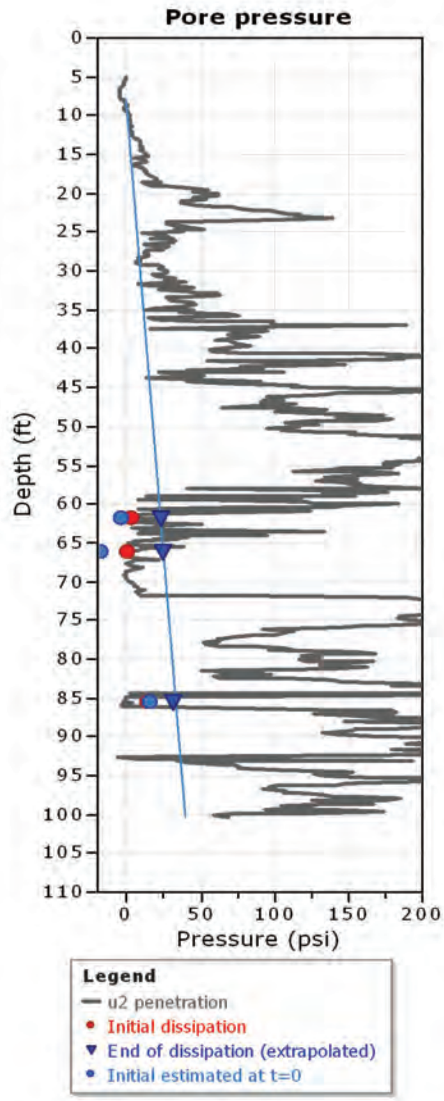
where: M is the 1-D constrained modulus and γ_w is the unit weight of water, in compatible units.

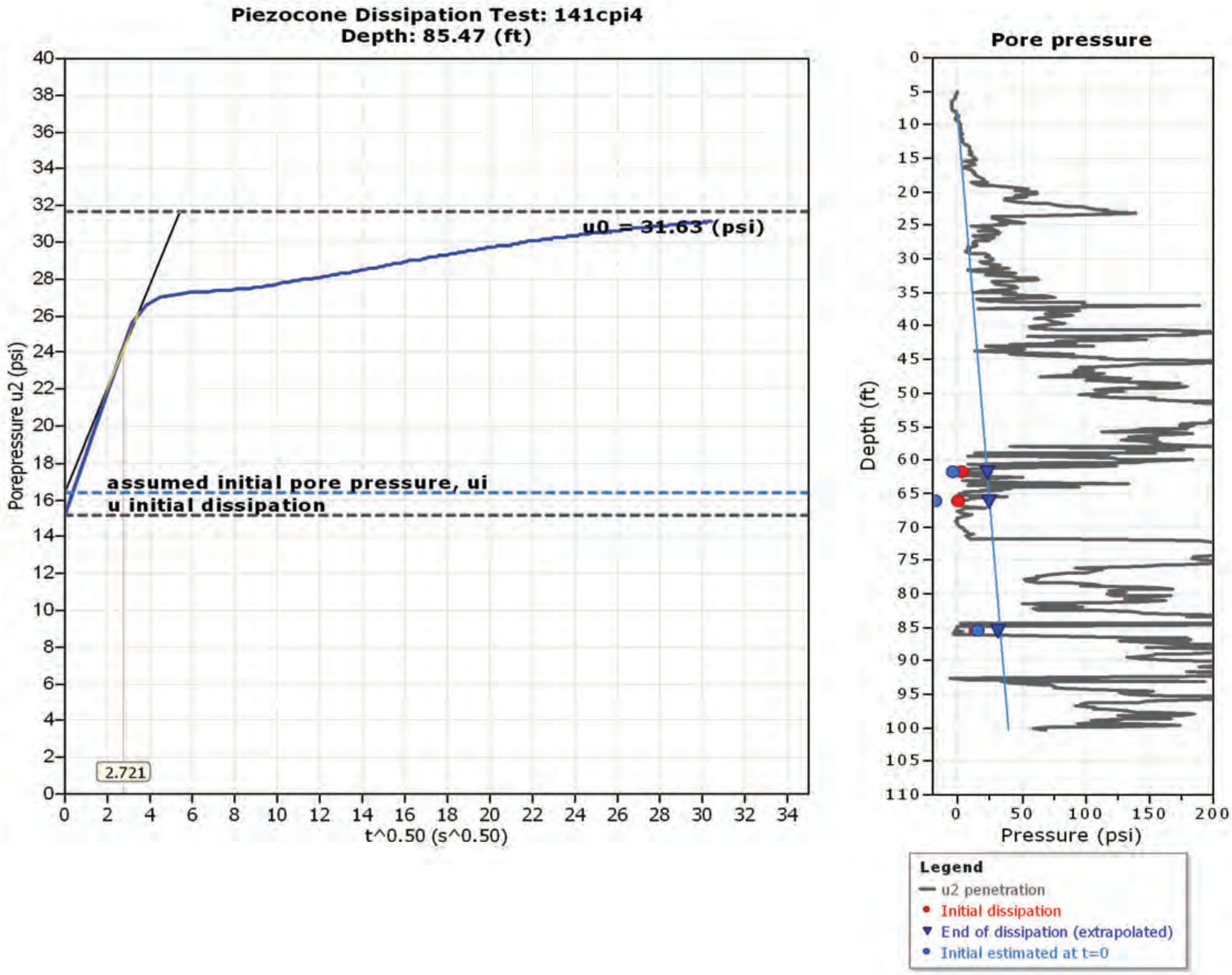
Tabular results

CPTU Borehole	Depth (ft)	$(t_{50})^{0.50}$	t_{50} (s)	t_{50} (years)	G/S_u	c_h (ft²/s)	c_h (ft²/year)	M (tsf)	k_h (ft/s)
141cpi4	61.84	2.2	5	1.56E-007	500.00	5.77E-003	181807	1000.00	1.80E-007
141cpi4	66.27	1.7	3	9.10E-008	500.00	9.89E-003	311953	1000.00	3.09E-007
141cpi4	85.47	2.7	7	2.35E-007	500.00	3.84E-003	120970	1000.00	1.20E-007


Piezocone Dissipation Test: 141cpi4
Depth: 61.84 (ft)
Porepressure u2 (psi)
u0 = 22.88 (psi)
u initial dissipation
2.22
t^0.50 (s^0.50)
assumed initial pore pressure, ui
Pore pressure
Depth (ft)
Pressure (psi)
Legend
u2 penetration
Initial dissipation
End of dissipation (extrapolated)
Initial estimated at t=0


Piezocone Dissipation Test: 141cpi4
Depth: 66.27 (ft)
Porepressure u2 (psi)
t^0.50 (s^0.50)
u0 = 24.11 (psi)
initial dissipation
1.594


Pore pressure
Depth (ft)
Pressure (psi)
Legend
u2 penetration
Initial dissipation
End of dissipation (extrapolated)
Initial estimated at t=0


Piezocone Dissipation Test: 141cpi4
Depth: 85.47 (ft)
u0 = 31.63 (psi)
assumed initial pore pressure, ui
u initial dissipation
2.721
Porepressure u2 (psi)
t^0.50 (s^0.50)
Pore pressure
Depth (ft)
Pressure (psi)
Legend
u2 penetration
Initial dissipation
End of dissipation (extrapolated)
Initial estimated at t=0

Dissipation Tests Results

Dissipation tests

Dissipation tests consists of stopping the piezocone penetration and observing porepressures (u) with elapsed time (t). The data are automatic recorded by the field computer and should take place until a minimum of 50% dissipation.

The porepressures are plotted as a function of square root of (t). The graphical technique suggested by Robertson and Campanella (1989), yields a value for t_{50}, which corresponds to the time for 50% consolidation.

The value of the coefficient of consolidation in the radial or horizontal direction c_h was then calculated by Houlsby and Teh's (1988) theory using the following equation:

$$c_h = \frac{T \times r^2 \times I_r^{0.5}}{t_{50}}$$

where:

T: time factor given by Houlsby and Teh's (1988) theory corresponding to the porepressure position
r: piezocone radius
I_r: stiffness index, equal to shear modulus G divided by the undrained strength of clay (S_u).
t_{50}: time corresponding to 50% consolidation

Permeability estimates based on dissipation test

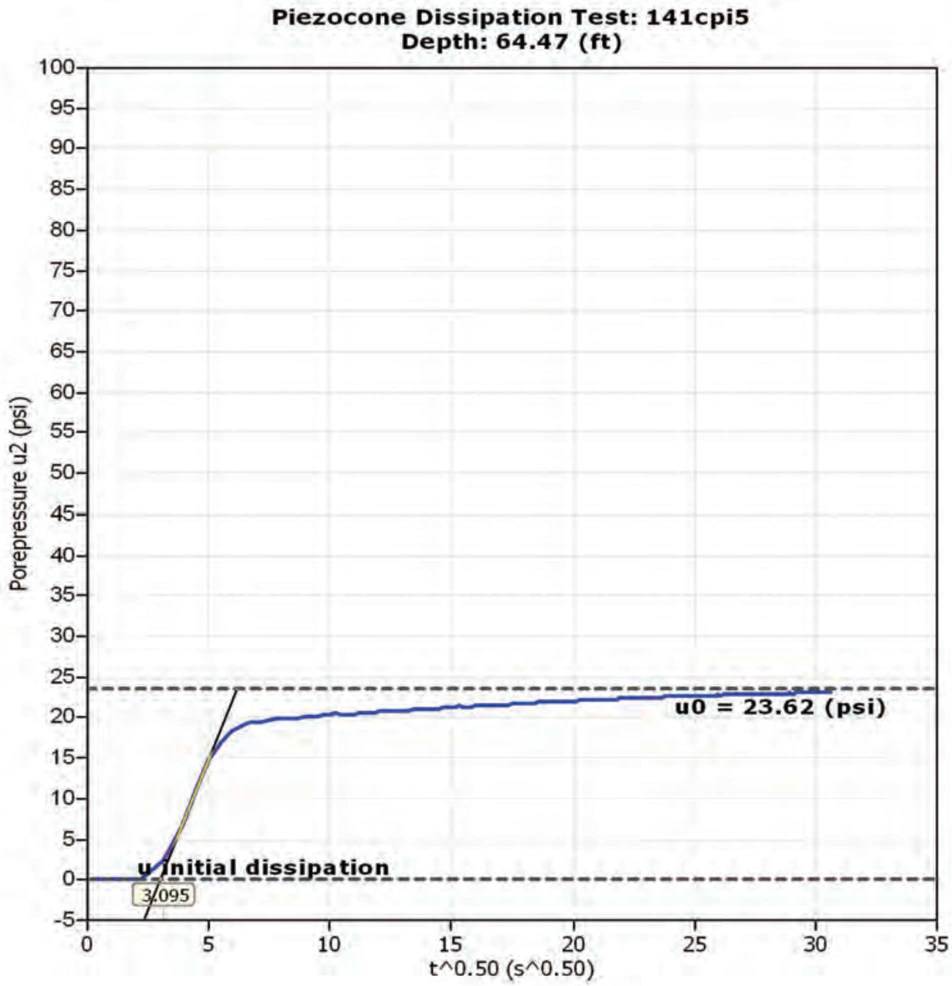
The dissipation of pore pressures during a CPTu dissipation test is controlled by the coefficient of consolidation in the horizontal direction (c_h) which is influenced by a combination of the soil permeability (k_h) and compressibility (M), as defined by the following:

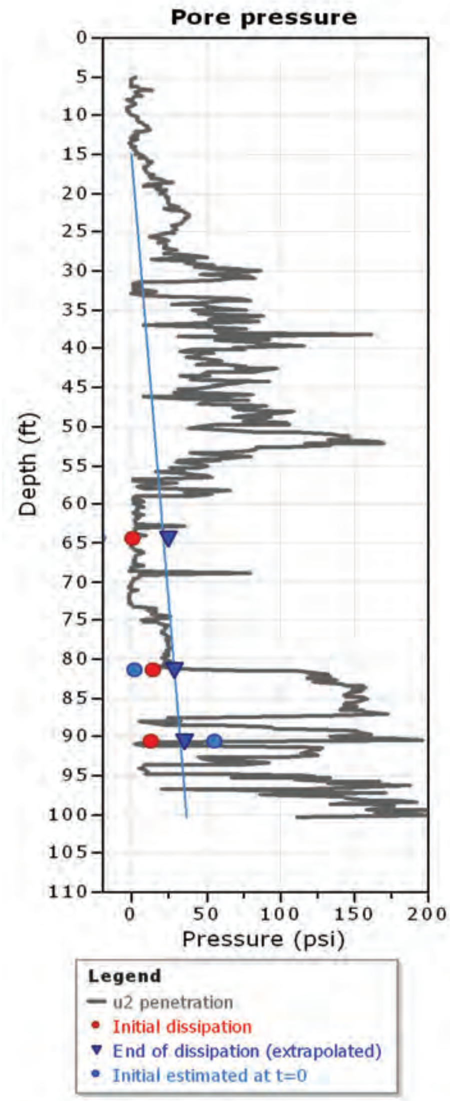
$$k_h = c_h \times \gamma_w / M$$

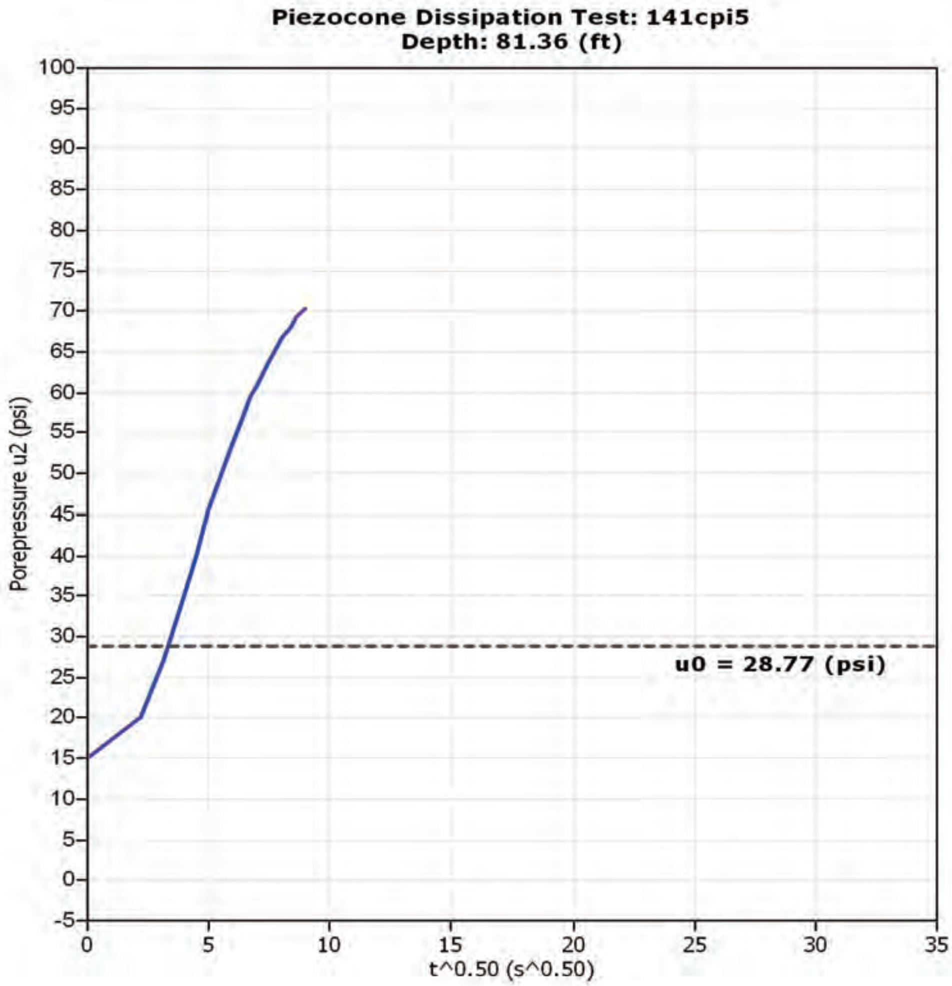
where: M is the 1-D constrained modulus and γ_w is the unit weight of water, in compatible units.

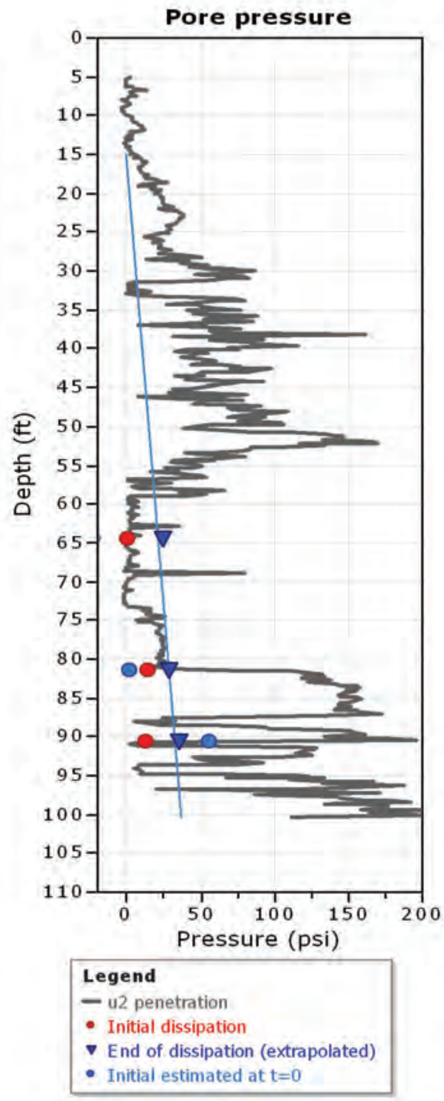
Tabular results

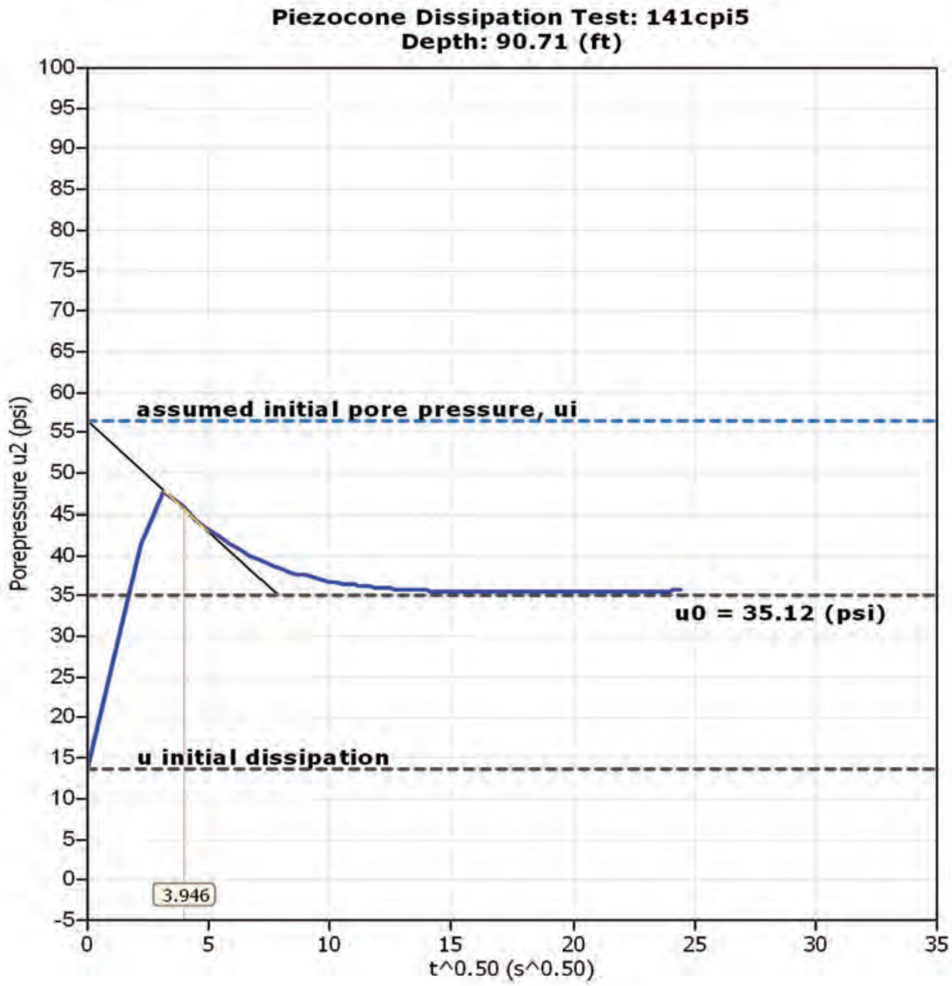
CPTU Borehole	Depth (ft)	$(t_{50})^{0.50}$	t_{50} (s)	t_{50} (years)	G/S_u	c_h (ft^2/s)	c_h (ft^2/year)	M (tsf)	k_h (ft/s)
141cpi5	64.47	3.1	10	3.04E-007	500.00	2.96E-003	93498	1000.00	9.26E-008
141cpi5	81.36	1.7	3	9.10E-008	500.00	9.89E-003	312008	1000.00	3.09E-007
141cpi5	90.71	3.9	16	4.94E-007	500.00	1.82E-003	57523	1000.00	5.69E-008


Piezocone Dissipation Test: 141cpi5
Depth: 64.47 (ft)
Porepressure u2 (psi)
t^0.50 (s^0.50)
u0 = 23.62 (psi)
u initial dissipation
3.095

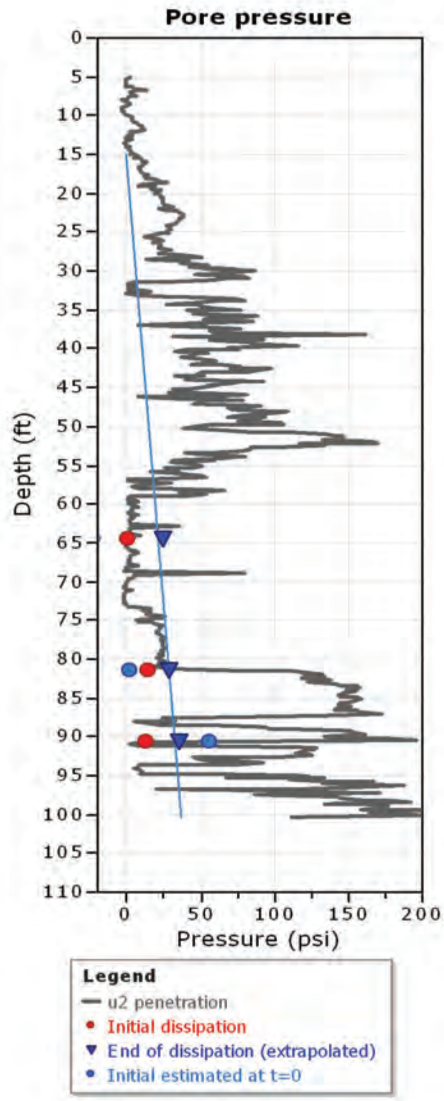

Pore pressure
Depth (ft)
Pressure (psi)
Legend
u2 penetration
Initial dissipation
End of dissipation (extrapolated)
Initial estimated at t=0


Piezocone Dissipation Test: 141cpi5
Depth: 81.36 (ft)
Porepressure u2 (psi)
t^0.50 (s^0.50)
u0 = 28.77 (psi)


Pore pressure
Depth (ft)
Pressure (psi)
Legend
u2 penetration
Initial dissipation
End of dissipation (extrapolated)
Initial estimated at t=0



Piezocone Dissipation Test: 141cpi5
Depth: 90.71 (ft)
assumed initial pore pressure, ui
u0 = 35.12 (psi)
u initial dissipation
3.946
Porepressure u2 (psi)
t^0.50 (s^0.50)



Pore pressure
Depth (ft)
Pressure (psi)
Legend
u2 penetration
Initial dissipation
End of dissipation (extrapolated)
Initial estimated at t=0

Dissipation Tests Results

Dissipation tests

Dissipation tests consists of stopping the piezocone penetration and observing porepressures (u) with elapsed time (t). The data are automatic recorded by the field computer and should take place until a minimum of 50% dissipation.

The porepressures are plotted as a function of square root of (t). The graphical technique suggested by Robertson and Campanella (1989), yields a value for t_{50}, which corresponds to the time for 50% consolidation.

The value of the coefficient of consolidation in the radial or horizontal direction c_h was then calculated by Houlsby and Teh's (1988) theory using the following equation:

$$c_h = \frac{T \times r^2 \times I_r^{0.5}}{t_{50}}$$

where:

T: time factor given by Houlsby and Teh's (1988) theory corresponding to the porepressure position
r: piezocone radius
I_r: stiffness index, equal to shear modulus G divided by the undrained strength of clay (S_u).
t_{50}: time corresponding to 50% consolidation

Permeability estimates based on dissipation test

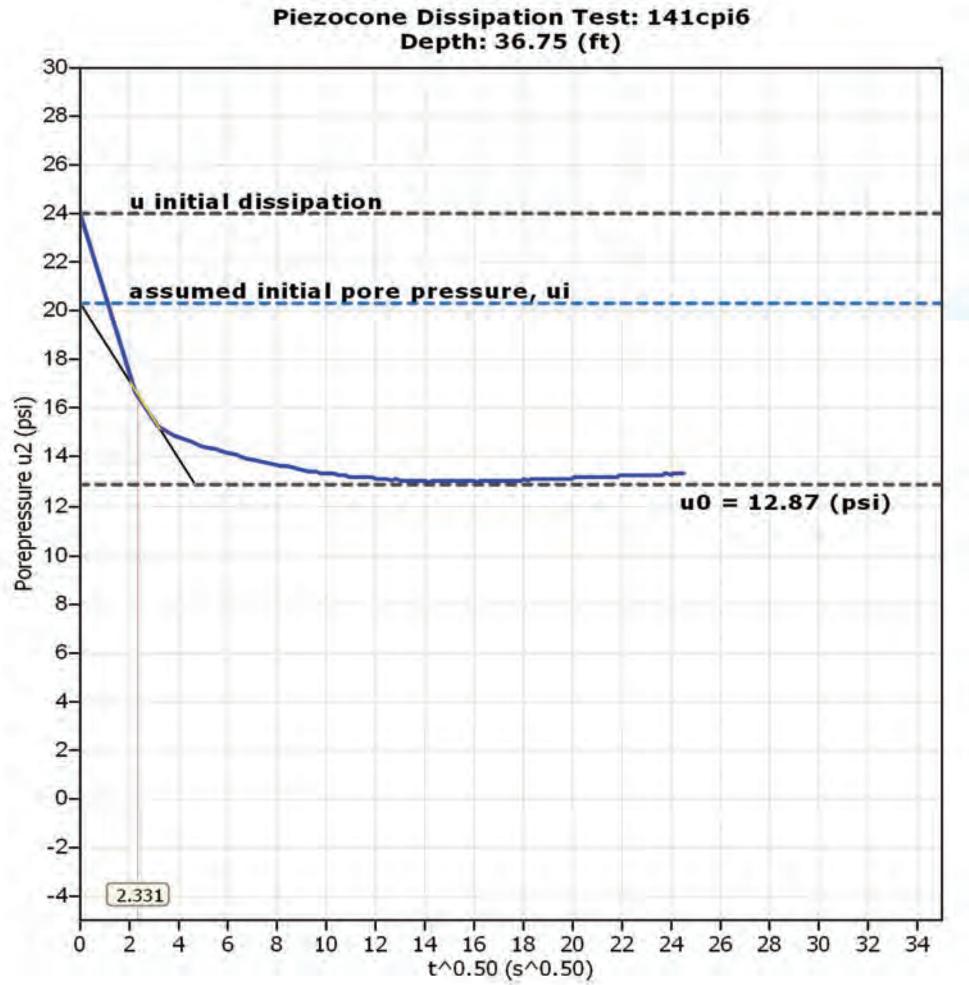
The dissipation of pore pressures during a CPTu dissipation test is controlled by the coefficient of consolidation in the horizontal direction (c_h) which is influenced by a combination of the soil permeability (k_h) and compressibility (M), as defined by the following:

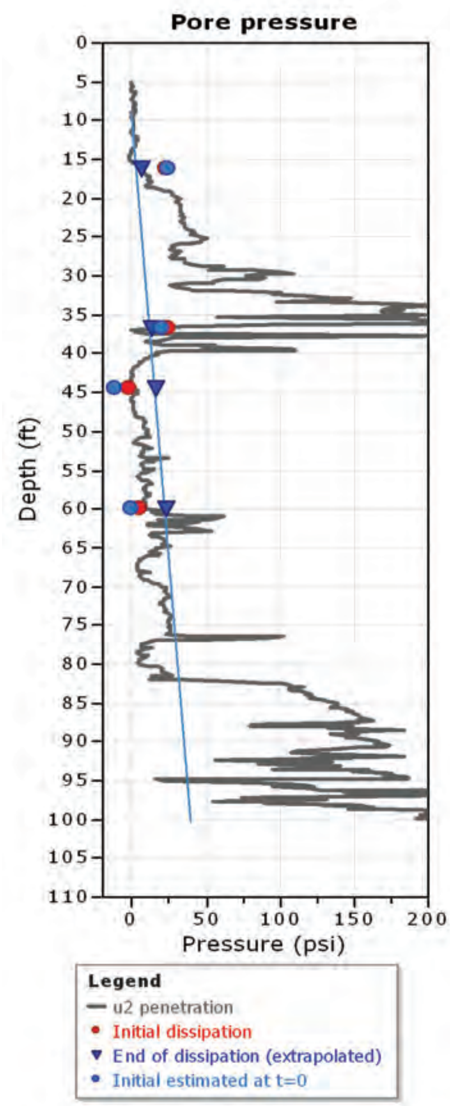
$$k_h = c_h \times \gamma_w / M$$

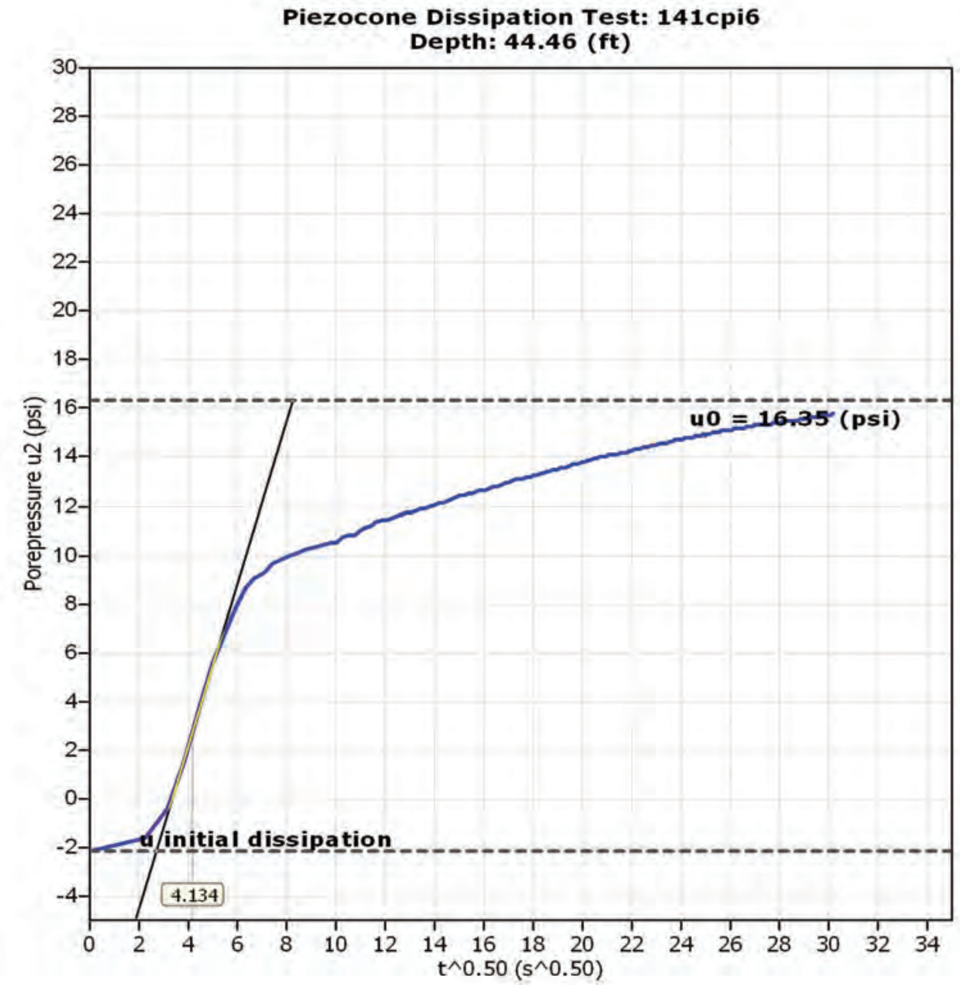
where: M is the 1-D constrained modulus and γ_w is the unit weight of water, in compatible units.

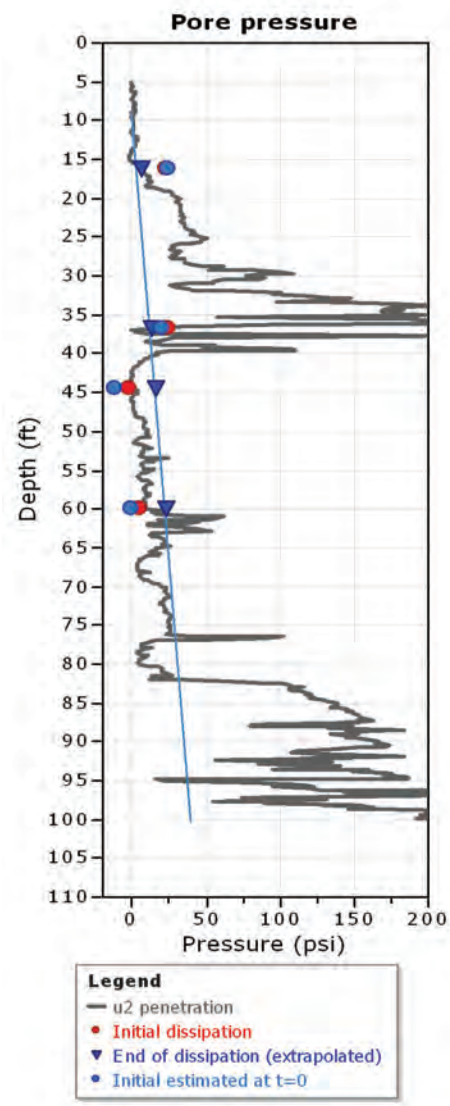
Tabular results

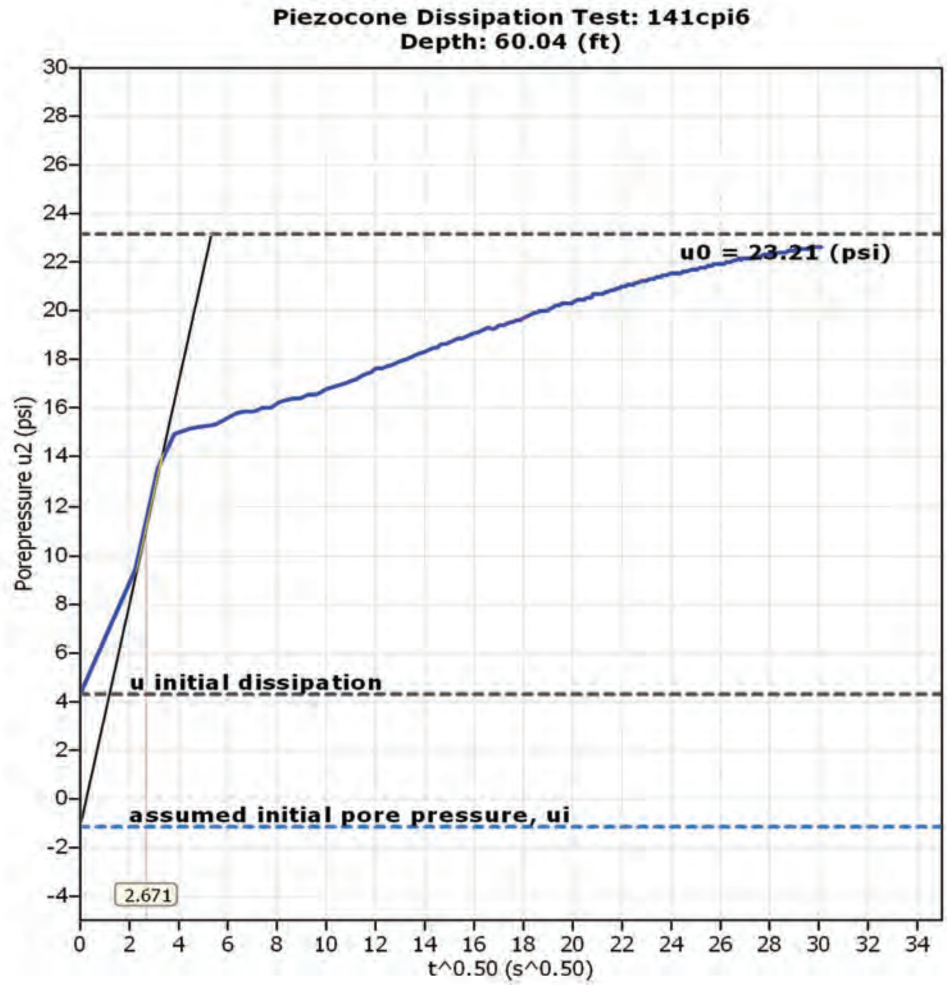
CPTU Borehole	Depth (ft)	$(t_{50})^{0.50}$	t_{50} (s)	t_{50} (years)	G/S_u	c_h (ft^2/s)	c_h ($ft^2/year$)	M (tsf)	k_h (ft/s)
141cpi6	36.75	2.3	5	1.72E-007	500.00	5.22E-003	164764	1000.00	1.63E-007
141cpi6	44.46	4.1	17	5.42E-007	500.00	1.66E-003	52401	1000.00	5.19E-008
141cpi6	60.04	2.7	7	2.26E-007	500.00	3.98E-003	125528	1000.00	1.24E-007
141cpi6	16.08	5.9	35	1.10E-006	500.00	8.20E-004	25853	1000.00	2.56E-008

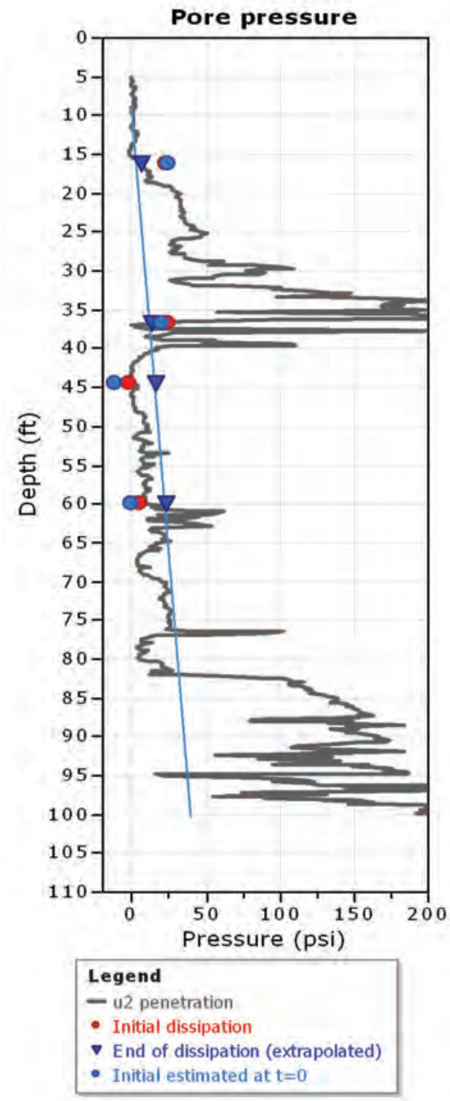

Piezocone Dissipation Test: 141cpi6
Depth: 36.75 (ft)
u initial dissipation
assumed initial pore pressure, ui
u0 = 12.87 (psi)
2.331
Porepressure u2 (psi)
t^0.50 (s^0.50)

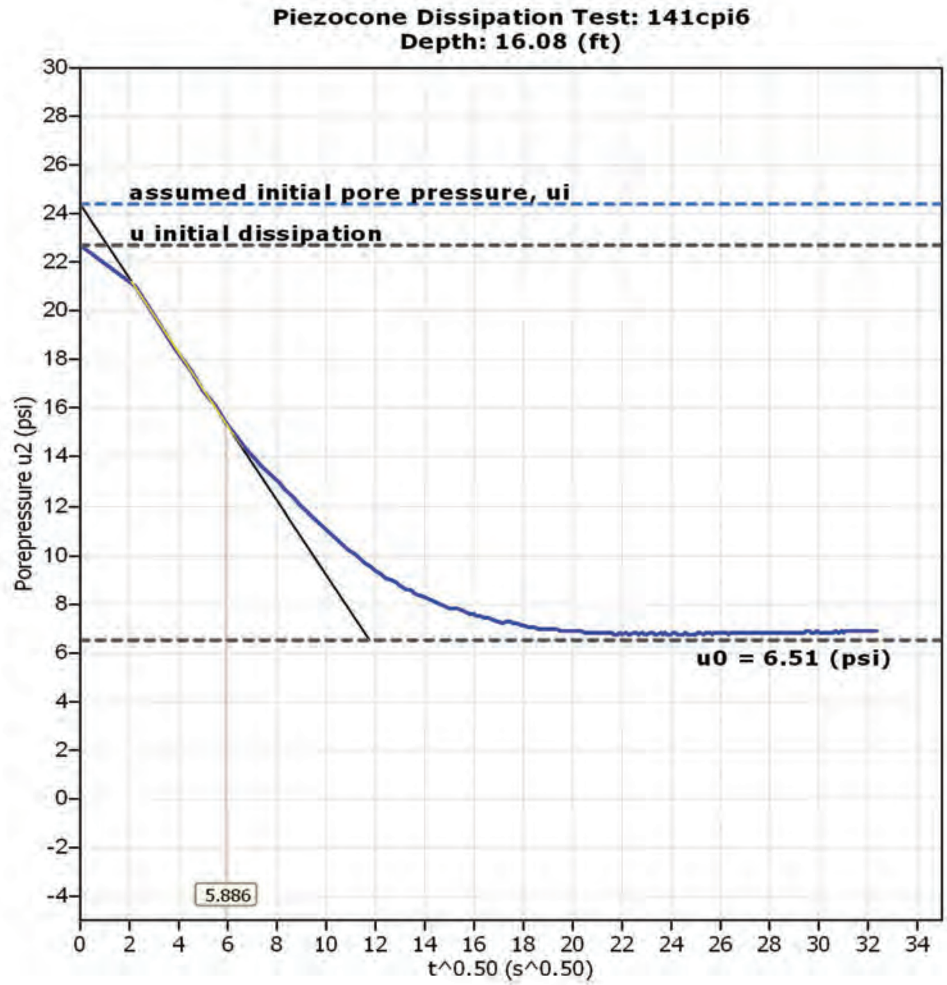

Pore pressure
Depth (ft)
Pressure (psi)
Legend
u2 penetration
Initial dissipation
End of dissipation (extrapolated)
Initial estimated at t=0

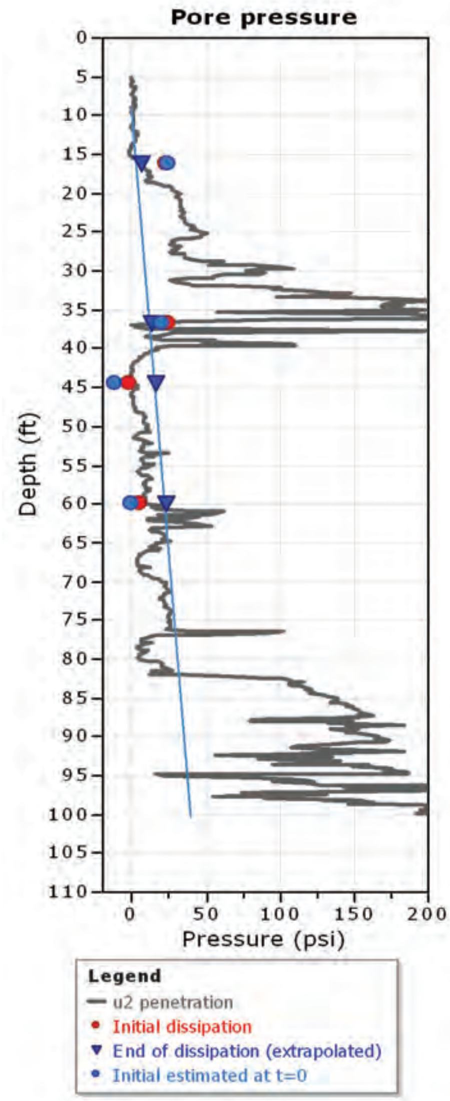

Piezocone Dissipation Test: 141cpi6
Depth: 44.46 (ft)
Porepressure u2 (psi)
t^0.50 (s^0.50)
u0 = 16.35 (psi)
u initial dissipation
4.134


Pore pressure
Depth (ft)
Pressure (psi)
Legend
u2 penetration
Initial dissipation
End of dissipation (extrapolated)
Initial estimated at t=0


Piezocone Dissipation Test: 141cpi6
Depth: 60.04 (ft)
u0 = 23.21 (psi)
u initial dissipation
assumed initial pore pressure, ui
2.671
Porepressure u2 (psi)
t^0.50 (s^0.50)


Pore pressure
Depth (ft)
Pressure (psi)
Legend
u2 penetration
Initial dissipation
End of dissipation (extrapolated)
Initial estimated at t=0


Piezocone Dissipation Test: 141cpi6
Depth: 16.08 (ft)
assumed initial pore pressure, ui
u initial dissipation
u0 = 6.51 (psi)
5.886
Porepressure u2 (psi)
t^0.50 (s^0.50)


Pore pressure
Depth (ft)
Pressure (psi)
Legend
u2 penetration
Initial dissipation
End of dissipation (extrapolated)
Initial estimated at t=0

Dissipation Tests Results

Dissipation tests

Dissipation tests consists of stopping the piezocone penetration and observing porepressures (u) with elapsed time (t). The data are automatic recorded by the field computer and should take place until a minimum of 50% dissipation.

The porepressures are plotted as a function of square root of (t). The graphical technique suggested by Robertson and Campanella (1989), yields a value for t_{50}, which corresponds to the time for 50% consolidation.

The value of the coefficient of consolidation in the radial or horizontal direction c_h was then calculated by Houlsby and Teh's (1988) theory using the following equation:

$$c_h = \frac{T \times r^2 \times I_r^{0.5}}{t_{50}}$$

where:

T: time factor given by Houlsby and Teh's (1988) theory corresponding to the porepressure position
r: piezocone radius
I_r: stiffness index, equal to shear modulus G divided by the undrained strength of clay (S_u).
t_{50}: time corresponding to 50% consolidation

Permeability estimates based on dissipation test

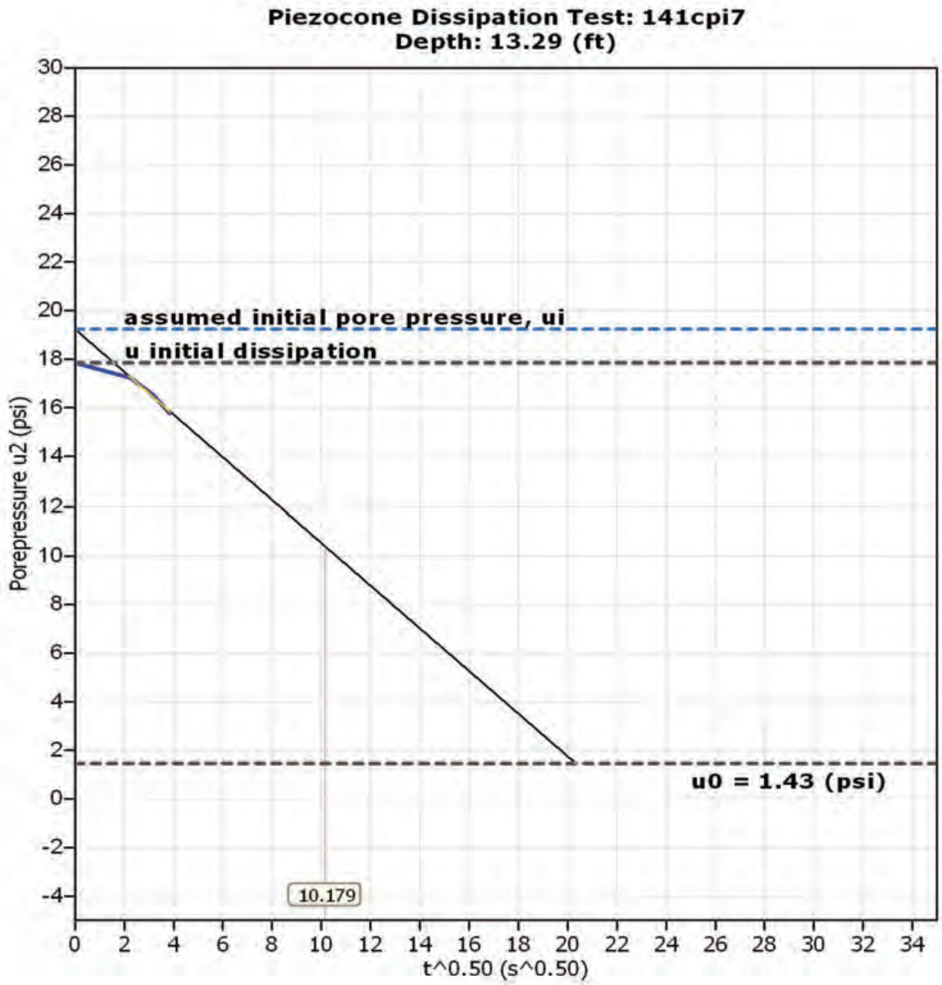
The dissipation of pore pressures during a CPTu dissipation test is controlled by the coefficient of consolidation in the horizontal direction (c_h) which is influenced by a combination of the soil permeability (k_h) and compressibility (M), as defined by the following:

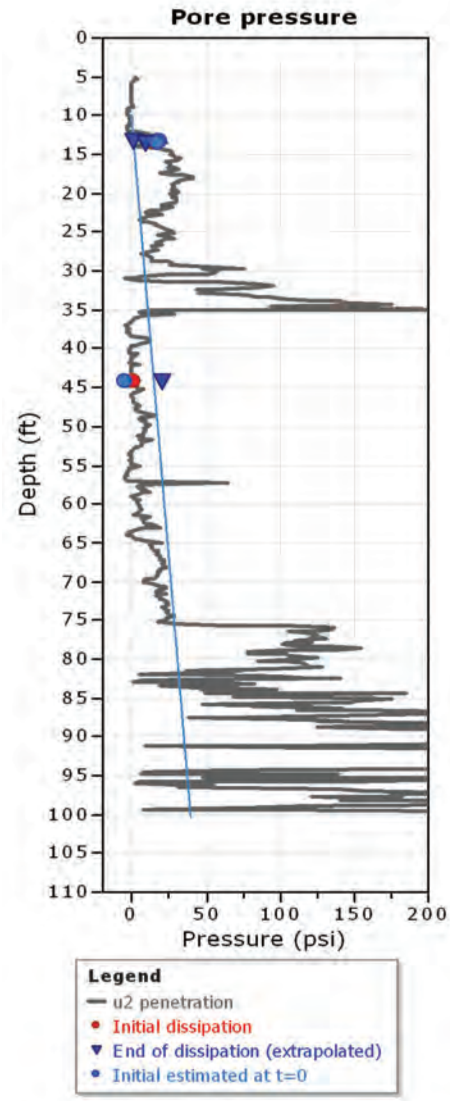
$$k_h = c_h \times \gamma_w / M$$

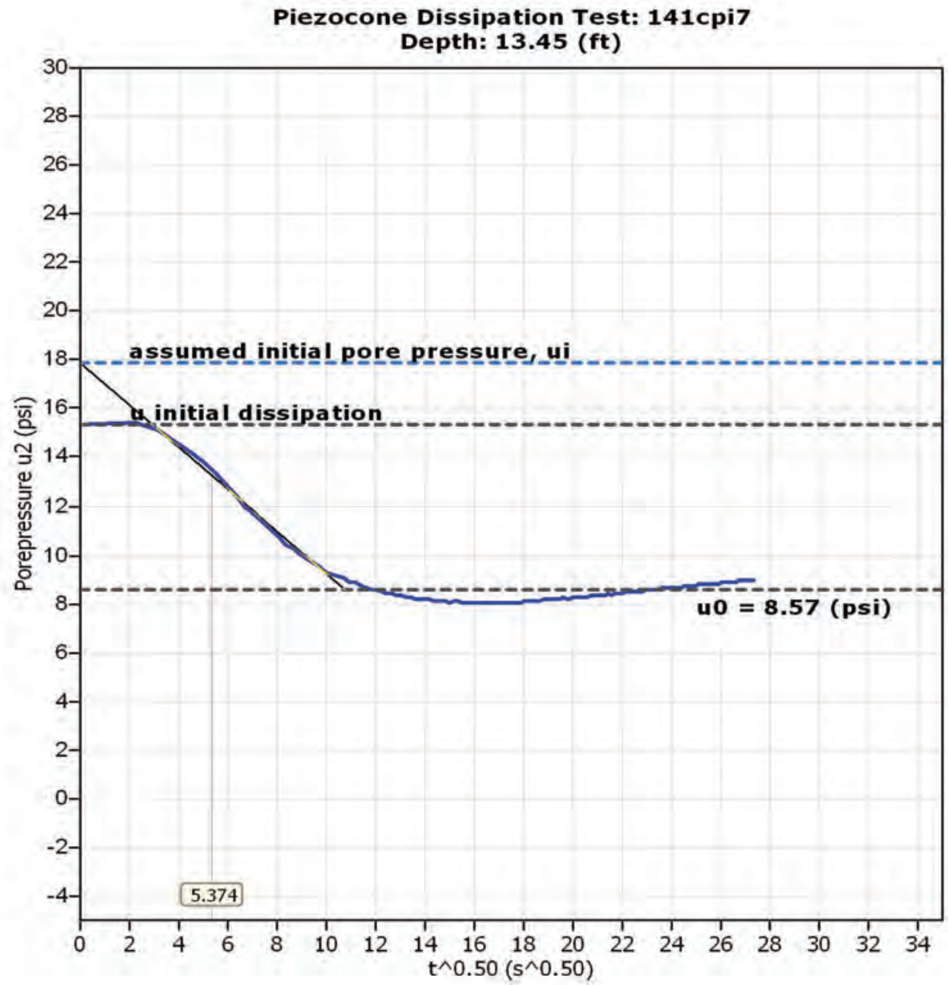
where: M is the 1-D constrained modulus and γ_w is the unit weight of water, in compatible units.

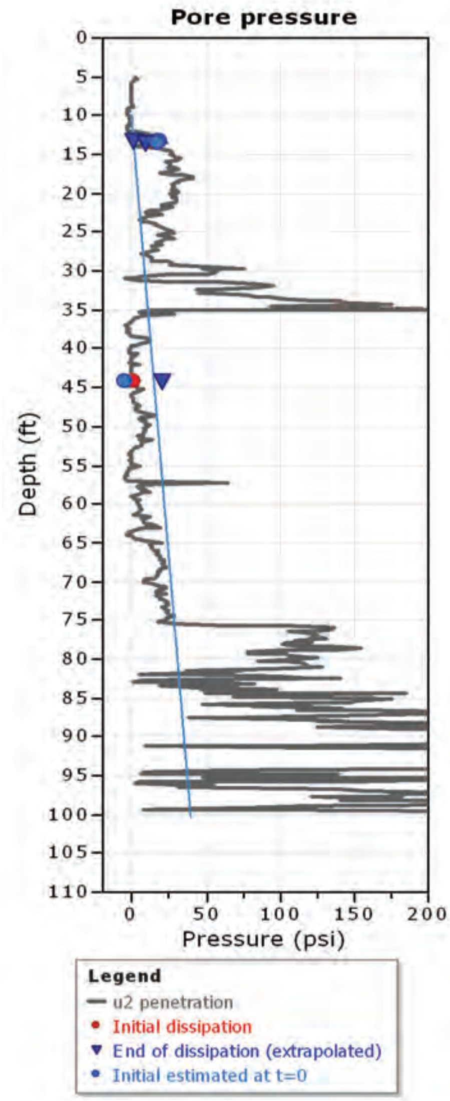
Tabular results

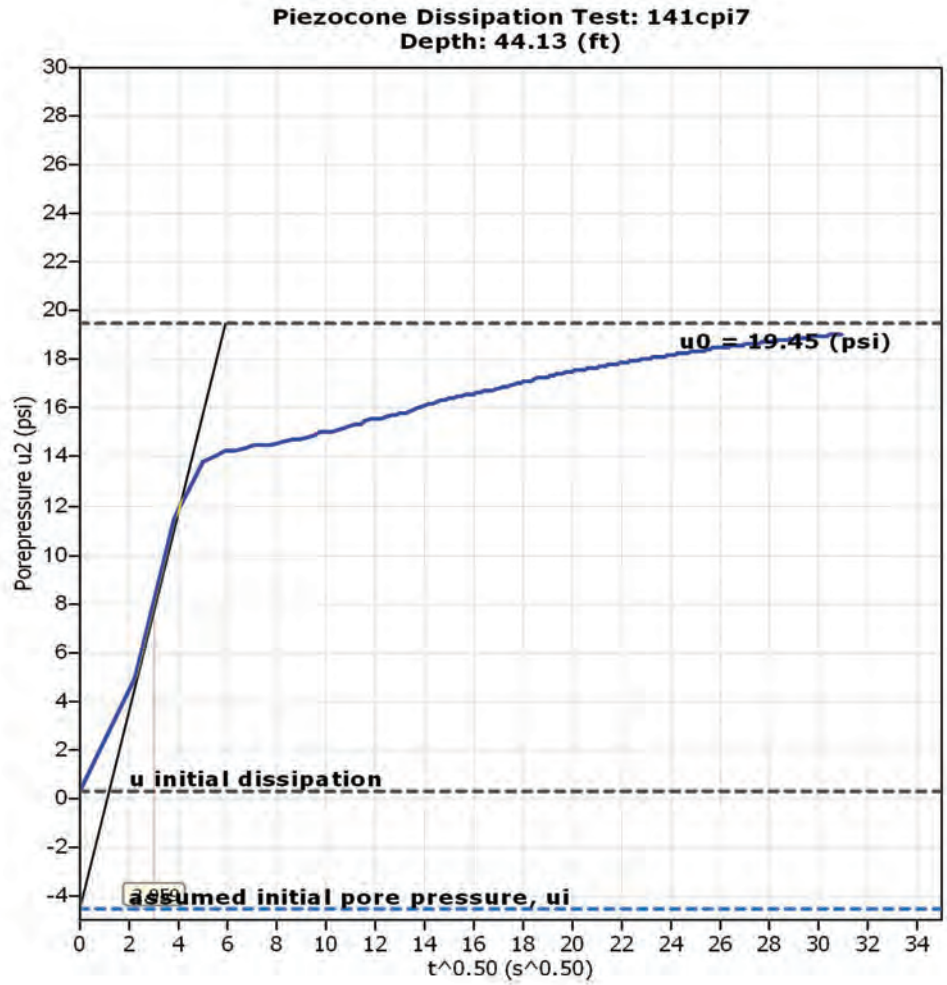
CPTU Borehole	Depth (ft)	$(t_{50})^{0.50}$	t_{50} (s)	t_{50} (years)	G/S_u	c_h (ft^2/s)	c_h ($ft^2/year$)	M (tsf)	k_h (ft/s)
141cpi7	13.29	10.2	104	3.29E-006	500.00	2.74E-004	8645	1000.00	8.56E-009
141cpi7	13.45	5.4	29	9.16E-007	500.00	9.83E-004	31009	1000.00	3.07E-008
141cpi7	44.13	3.0	9	2.78E-007	500.00	3.24E-003	102282	1000.00	1.01E-007

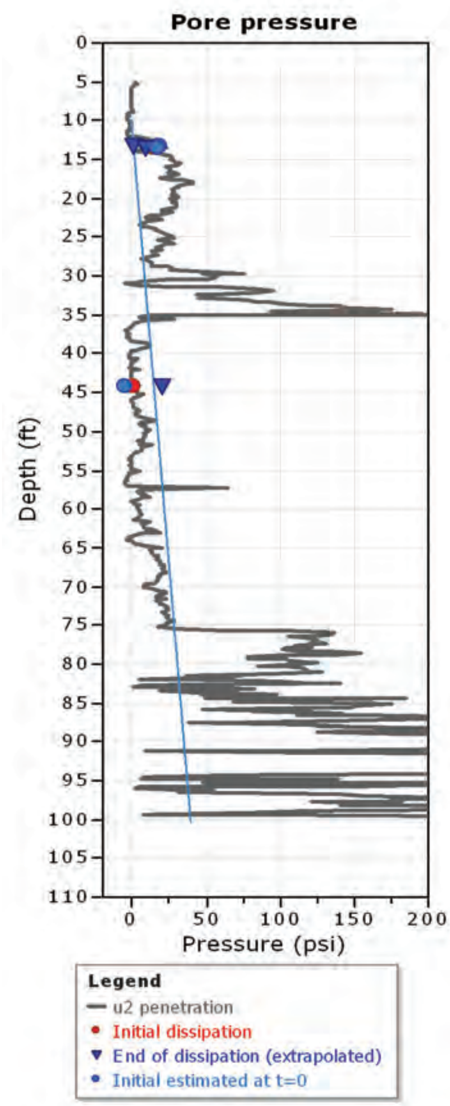

Piezocone Dissipation Test: 141cpi7
Depth: 13.29 (ft)
assumed initial pore pressure, ui
u initial dissipation
u0 = 1.43 (psi)
10.179
Porepressure u2 (psi)
t^0.50 (s^0.50)


Pore pressure
Depth (ft)
Pressure (psi)
Legend
u2 penetration
Initial dissipation
End of dissipation (extrapolated)
Initial estimated at t=0


Piezocone Dissipation Test: 141cpi7
Depth: 13.45 (ft)
assumed initial pore pressure, ui
u initial dissipation
u0 = 8.57 (psi)
5.374
Porepressure u2 (psi)
t^0.50 (s^0.50)


Pore pressure
Depth (ft)
Pressure (psi)
Legend
u2 penetration
Initial dissipation
End of dissipation (extrapolated)
Initial estimated at t=0


Piezocone Dissipation Test: 141cpi7
Depth: 44.13 (ft)
Porepressure u2 (psi)
t^0.50 (s^0.50)
u0 = 19.45 (psi)
u initial dissipation
assumed initial pore pressure, ui


Pore pressure
Depth (ft)
Pressure (psi)
Legend
u2 penetration
Initial dissipation
End of dissipation (extrapolated)
Initial estimated at t=0

Dissipation Tests Results

Dissipation tests

Dissipation tests consists of stopping the piezocone penetration and observing porepressures (u) with elapsed time (t). The data are automatic recorded by the field computer and should take place until a minimum of 50% dissipation.

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The value of the coefficient of consolidation in the radial or horizontal direction c_h was then calculated by Houlsby and Teh's (1988) theory using the following equation:

$$c_h = \frac{T \times r^2 \times I_r^{0.5}}{t_{50}}$$

where:

T: time factor given by Houlsby and Teh's (1988) theory corresponding to the porepressure position
r: piezocone radius
I_r: stiffness index, equal to shear modulus G divided by the undrained strength of clay (S_u).
t_{50}: time corresponding to 50% consolidation

Permeability estimates based on dissipation test

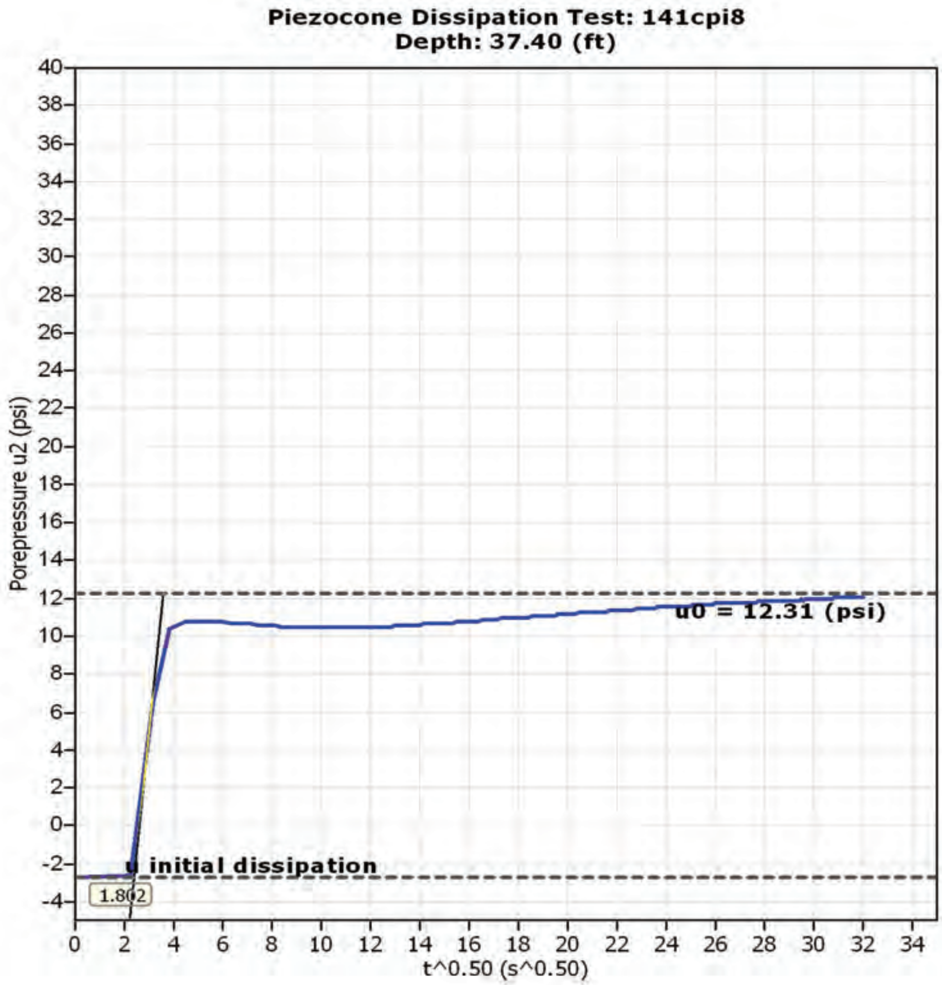
The dissipation of pore pressures during a CPTu dissipation test is controlled by the coefficient of consolidation in the horizontal direction (c_h) which is influenced by a combination of the soil permeability (k_h) and compressibility (M), as defined by the following:

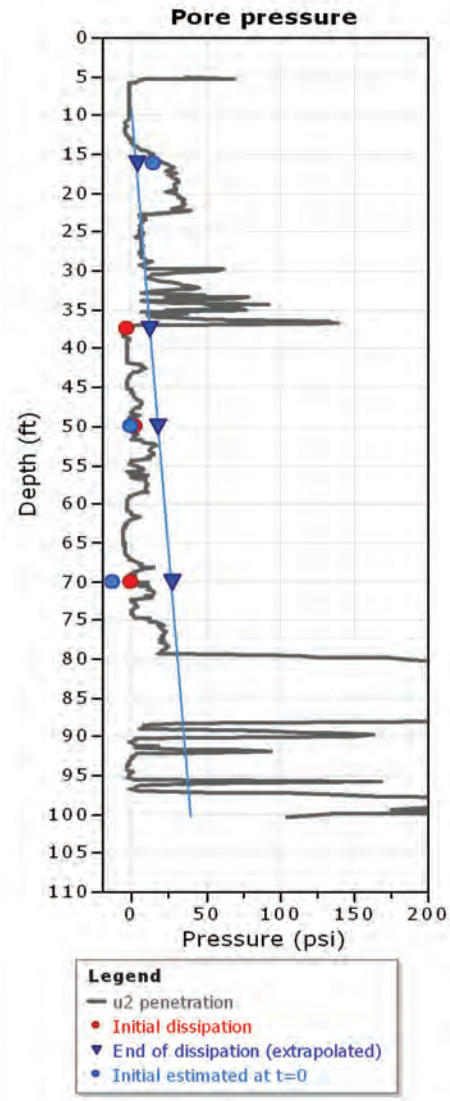
$$k_h = c_h \times \gamma_w / M$$

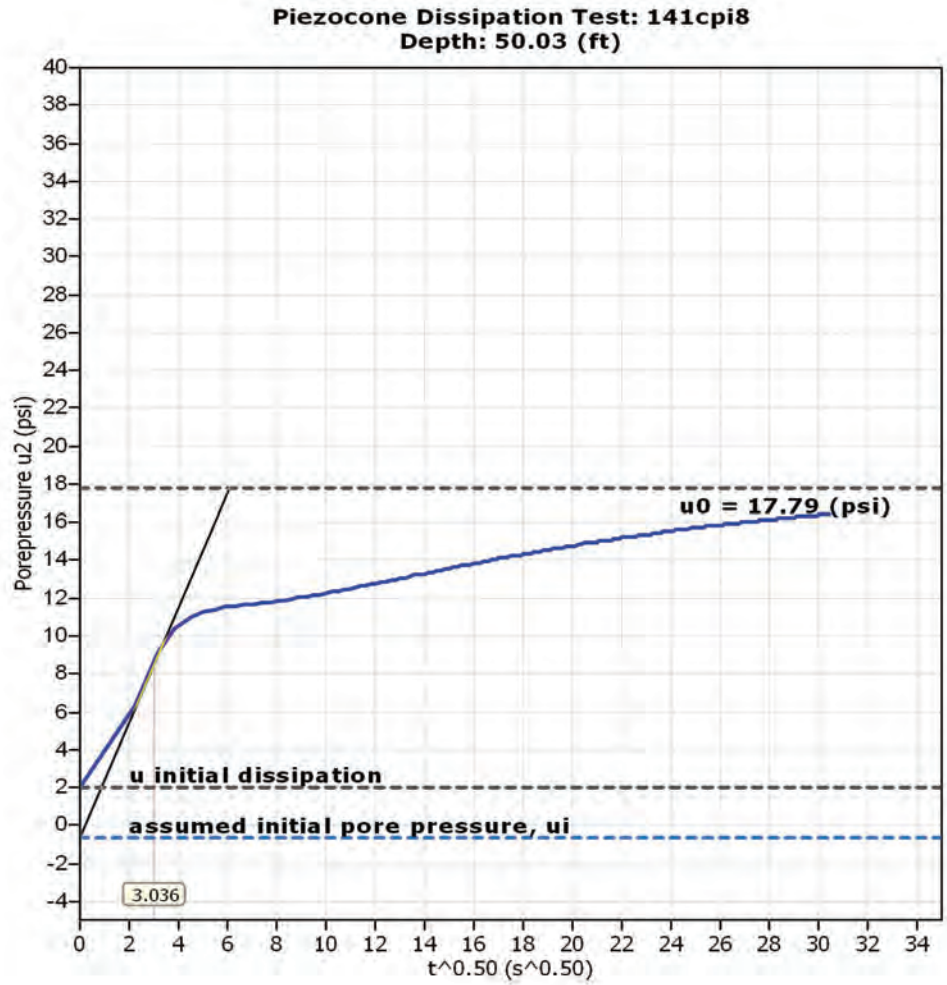
where: M is the 1-D constrained modulus and γ_w is the unit weight of water, in compatible units.

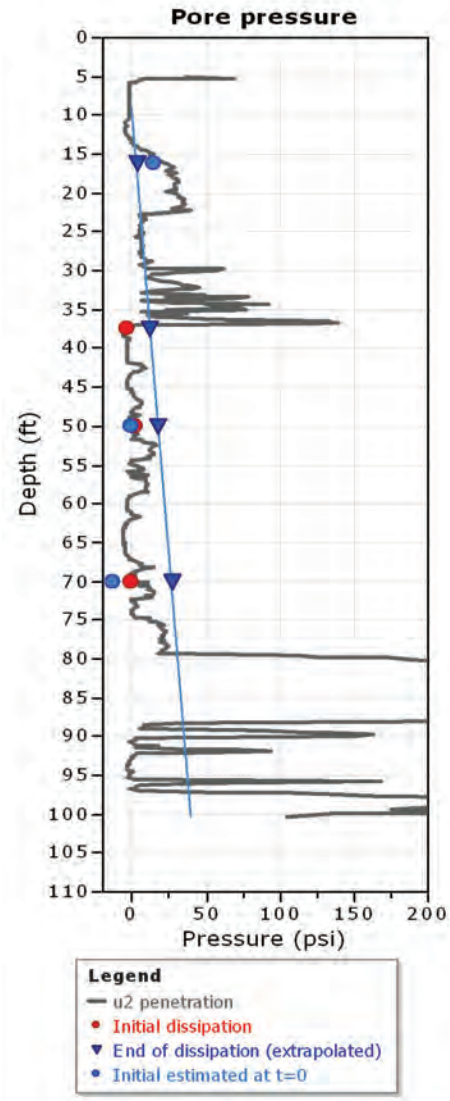
Tabular results

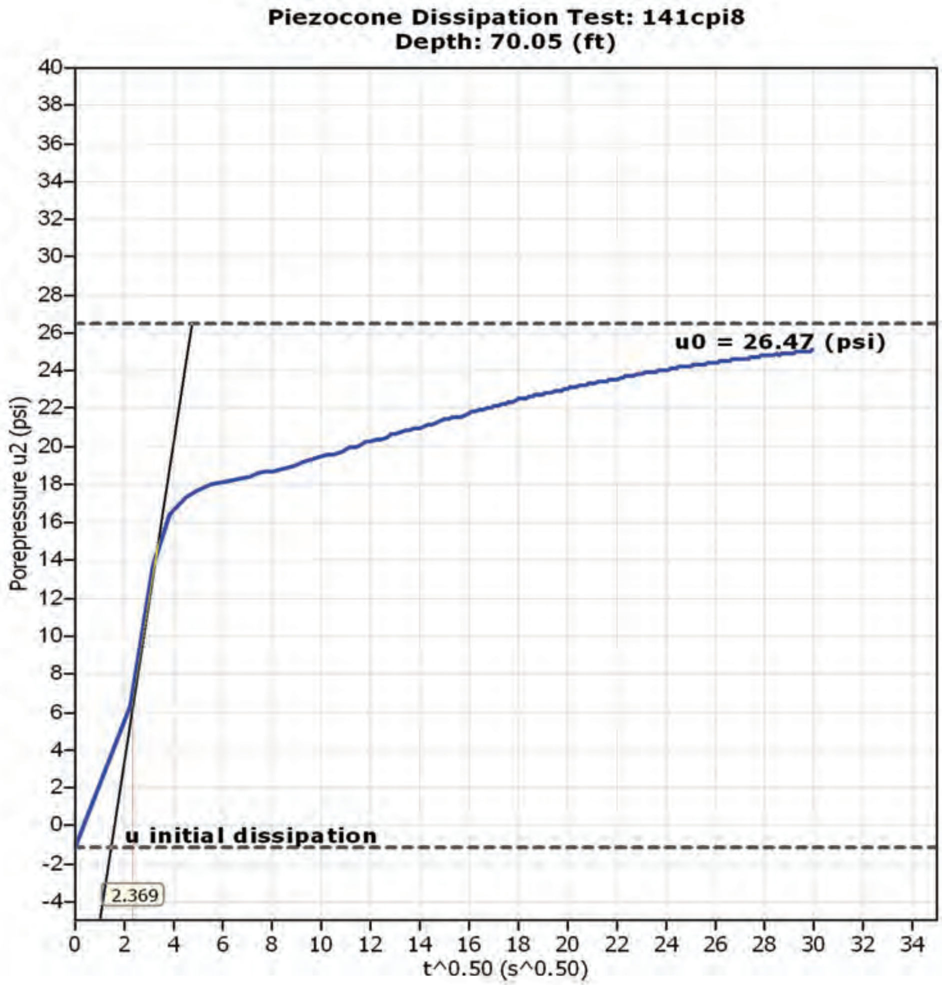
CPTU Borehole	Depth (ft)	$(t_{50})^{0.50}$	t_{50} (s)	t_{50} (years)	G/S_u	c_h (ft^2/s)	c_h ($ft^2/year$)	M (tsf)	k_h (ft/s)
141cpi8	37.40	1.8	3	1.03E-007	500.00	8.74E-003	275750	1000.00	2.73E-007
141cpi8	50.03	3.0	9	2.92E-007	500.00	3.08E-003	97186	1000.00	9.62E-008
141cpi8	70.05	2.4	6	1.78E-007	500.00	5.06E-003	159625	1000.00	1.58E-007
141cpi8	16.08	2.6	7	2.12E-007	500.00	4.24E-003	133798	1000.00	1.32E-007

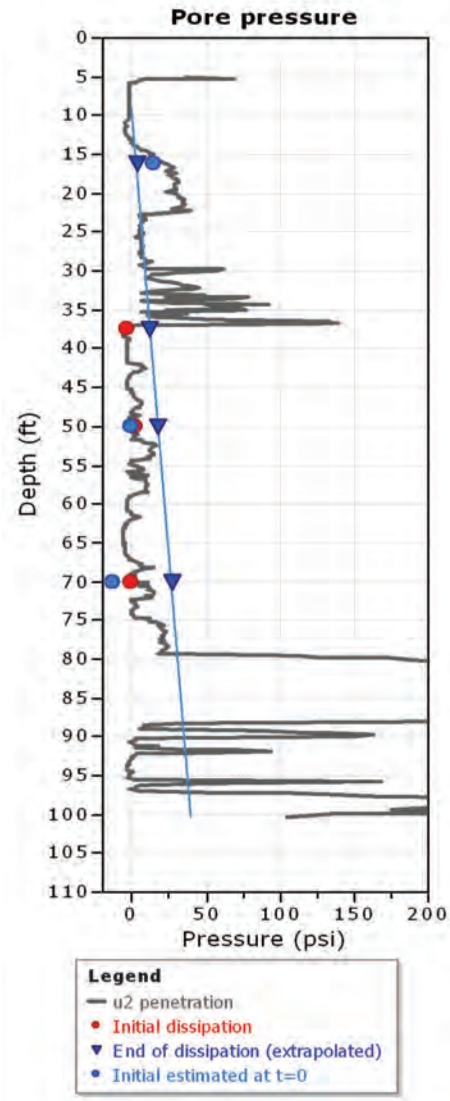

Piezocone Dissipation Test: 141cpi8
Depth: 37.40 (ft)
Porepressure u2 (psi)
t^0.50 (s^0.50)
u0 = 12.31 (psi)
u initial dissipation
1.802

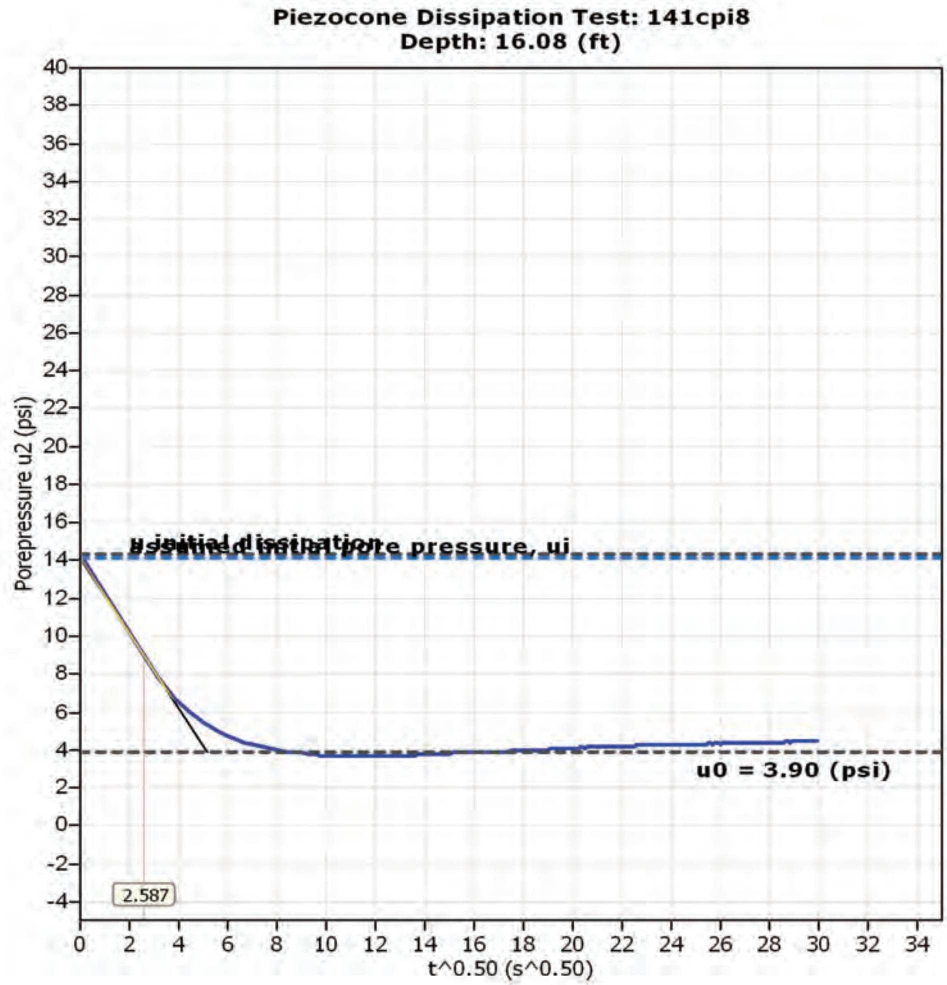

Pore pressure
Depth (ft)
Pressure (psi)
Legend
u2 penetration
Initial dissipation
End of dissipation (extrapolated)
Initial estimated at t=0

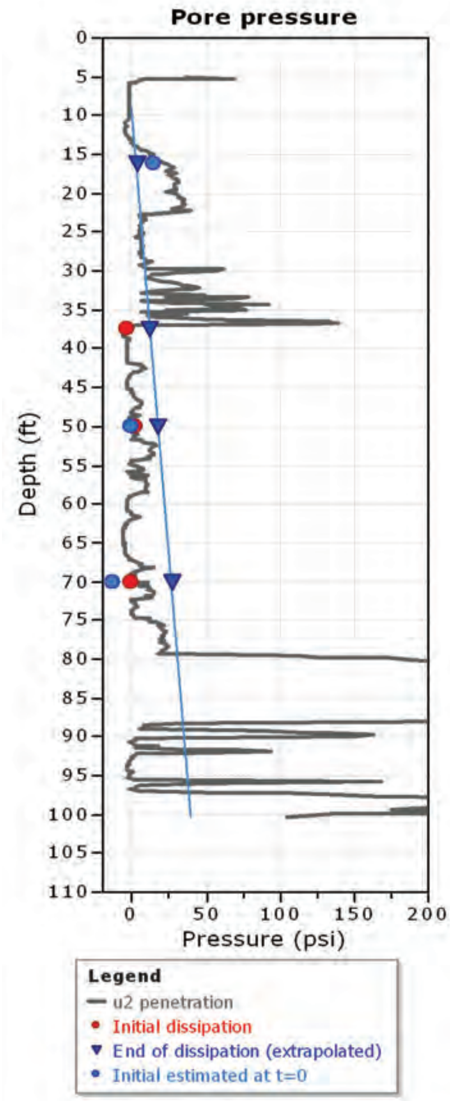

Piezocone Dissipation Test: 141cpi8
Depth: 50.03 (ft)
Porepressure u2 (psi)
u0 = 17.79 (psi)
u initial dissipation
assumed initial pore pressure, ui
3.036
t^0.50 (s^0.50)


Pore pressure
Depth (ft)
Pressure (psi)
Legend
u2 penetration
Initial dissipation
End of dissipation (extrapolated)
Initial estimated at t=0


Piezocone Dissipation Test: 141cpi8
Depth: 70.05 (ft)
u0 = 26.47 (psi)
u initial dissipation
2.369
Porepressure u2 (psi)
t^0.50 (s^0.50)


Pore pressure
Depth (ft)
Pressure (psi)
Legend
u2 penetration
Initial dissipation
End of dissipation (extrapolated)
Initial estimated at t=0


Piezocone Dissipation Test: 141cpi8
Depth: 16.08 (ft)
Porepressure u2 (psi)
t^0.50 (s^0.50)
Assumed initial pore pressure, ui
u initial dissipation
u0 = 3.90 (psi)
2.587


Pore pressure
Depth (ft)
Pressure (psi)
Legend
u2 penetration
Initial dissipation
End of dissipation (extrapolated)
Initial estimated at t=0

Dissipation Tests Results

Dissipation tests

Dissipation tests consists of stopping the piezocone penetration and observing porepressures (u) with elapsed time (t). The data are automatic recorded by the field computer and should take place until a minimum of 50% dissipation.

The porepressures are plotted as a function of square root of (t). The graphical technique suggested by Robertson and Campanella (1989), yields a value for t_{50}, which corresponds to the time for 50% consolidation.

The value of the coefficient of consolidation in the radial or horizontal direction c_h was then calculated by Houlsby and Teh's (1988) theory using the following equation:

$$c_h = \frac{T \times r^2 \times I_r^{0.5}}{t_{50}}$$

where:

T: time factor given by Houlsby and Teh's (1988) theory corresponding to the porepressure position
r: piezocone radius
I_r: stiffness index, equal to shear modulus G divided by the undrained strength of clay (S_u).
t_{50}: time corresponding to 50% consolidation

Permeability estimates based on dissipation test

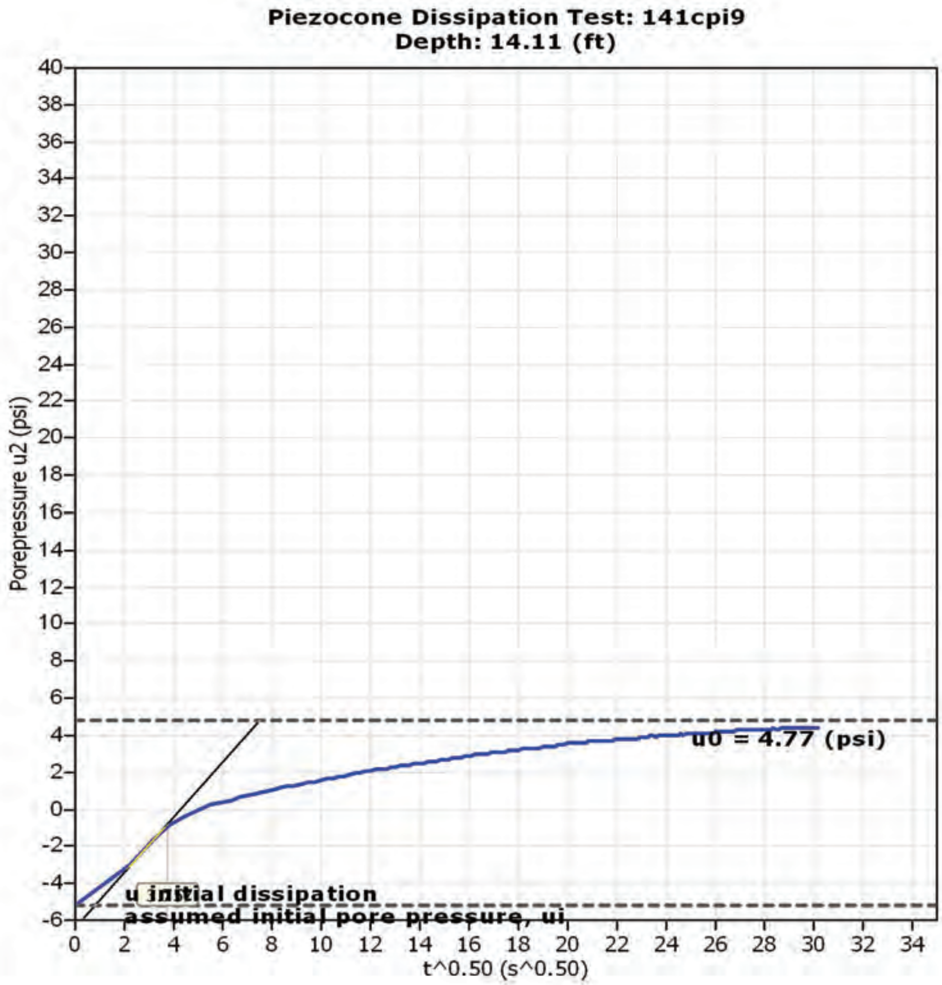
The dissipation of pore pressures during a CPTu dissipation test is controlled by the coefficient of consolidation in the horizontal direction (c_h) which is influenced by a combination of the soil permeability (k_h) and compressibility (M), as defined by the following:

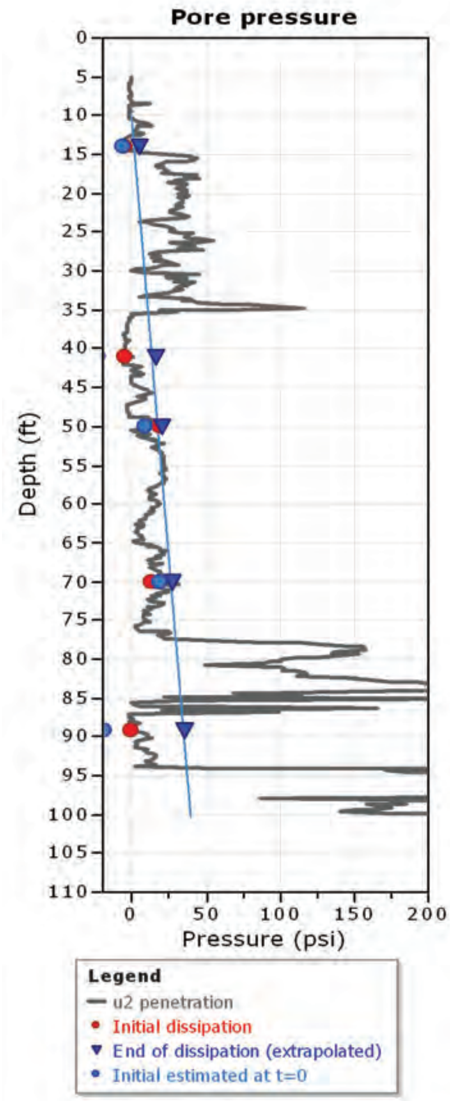
$$k_h = c_h \times \gamma_w / M$$

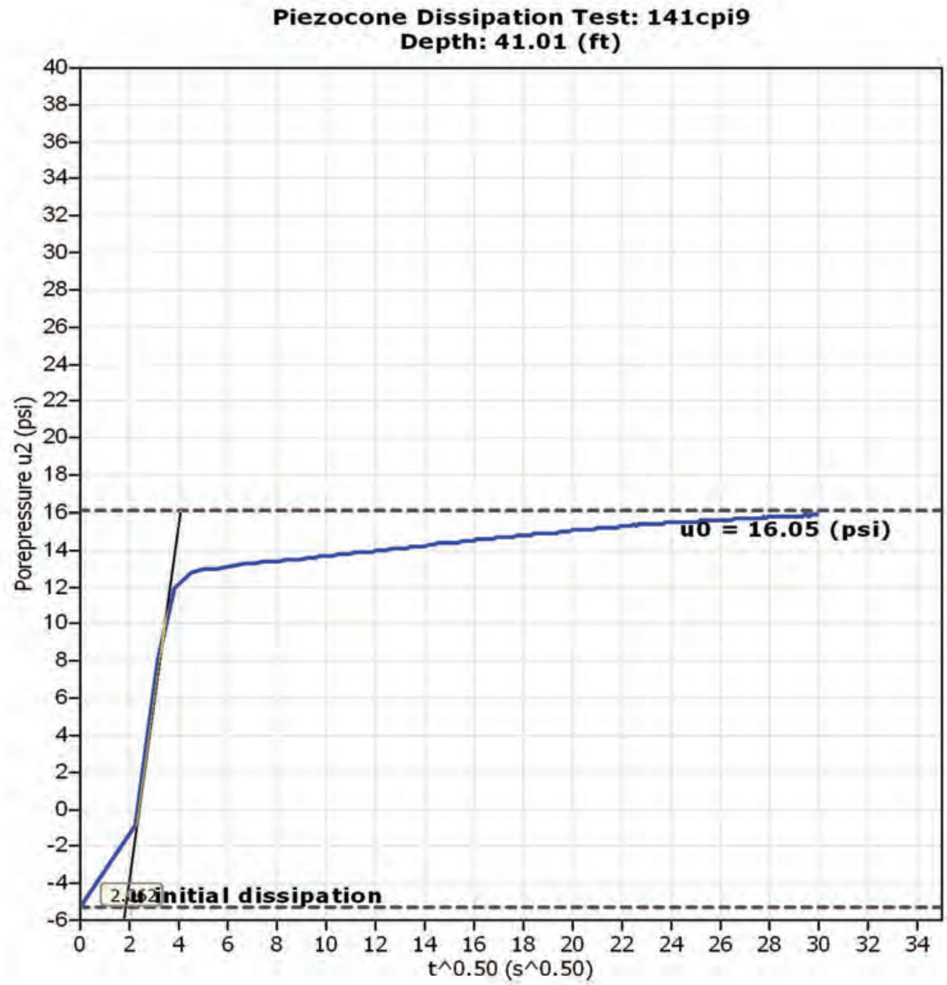
where: M is the 1-D constrained modulus and γ_w is the unit weight of water, in compatible units.

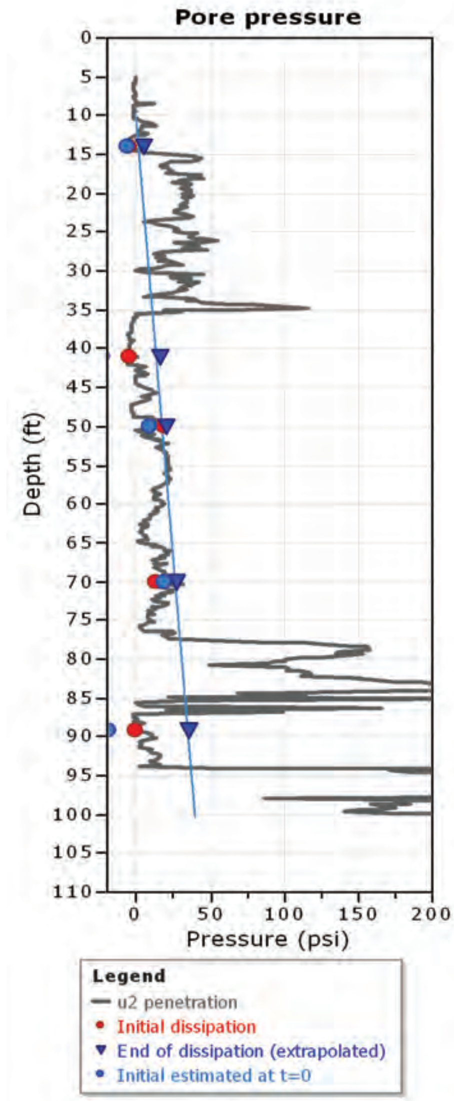
Tabular results

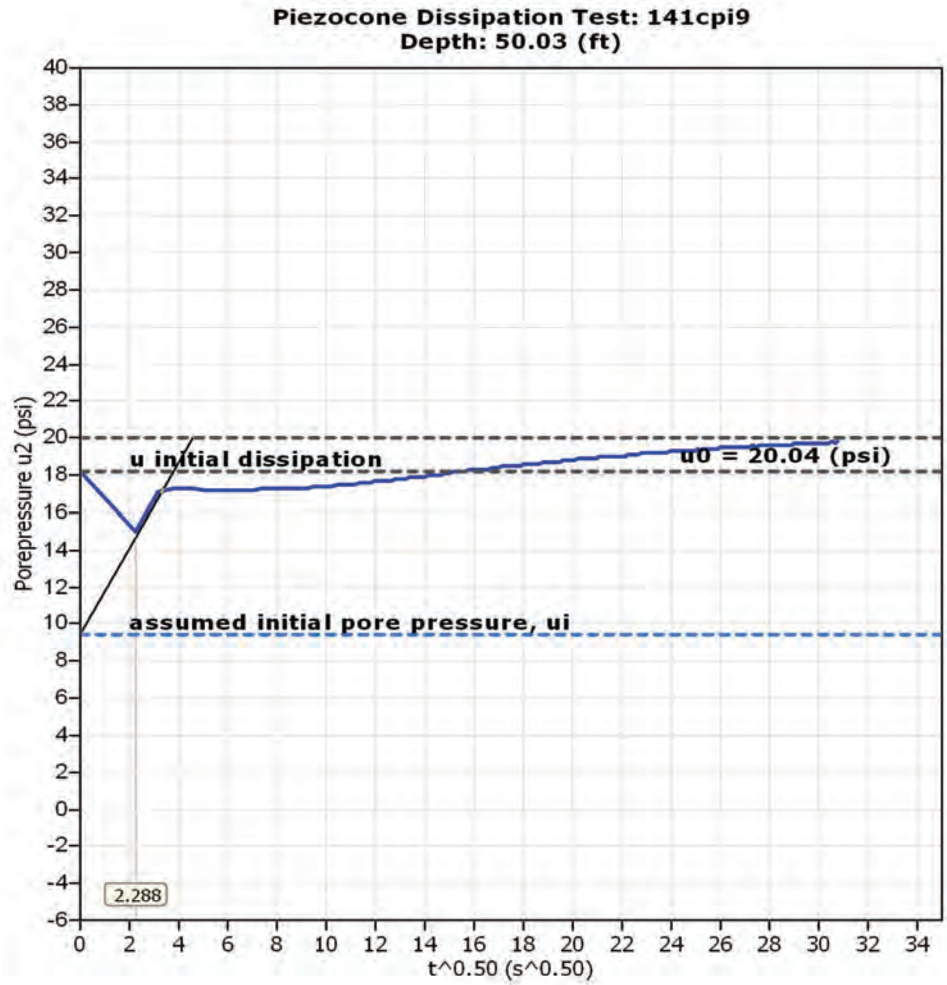
CPTU Borehole	Depth (ft)	$(t_{50})^{0.50}$	t_{50} (s)	t_{50} (years)	G/S_u	c_h (ft^2/s)	c_h ($ft^2/year$)	M (tsf)	k_h (ft/s)
141cpi9	14.11	3.8	14	4.48E-007	500.00	2.01E-003	63438	1000.00	6.28E-008
141cpi9	41.01	2.1	4	1.35E-007	500.00	6.68E-003	210611	1000.00	2.09E-007
141cpi9	50.03	2.3	5	1.66E-007	500.00	5.43E-003	171089	1000.00	1.69E-007
141cpi9	70.05	6.6	43	1.37E-006	500.00	6.58E-004	20766	1000.00	2.06E-008
141cpi9	89.24	2.5	6	2.02E-007	500.00	4.46E-003	140575	1000.00	1.39E-007

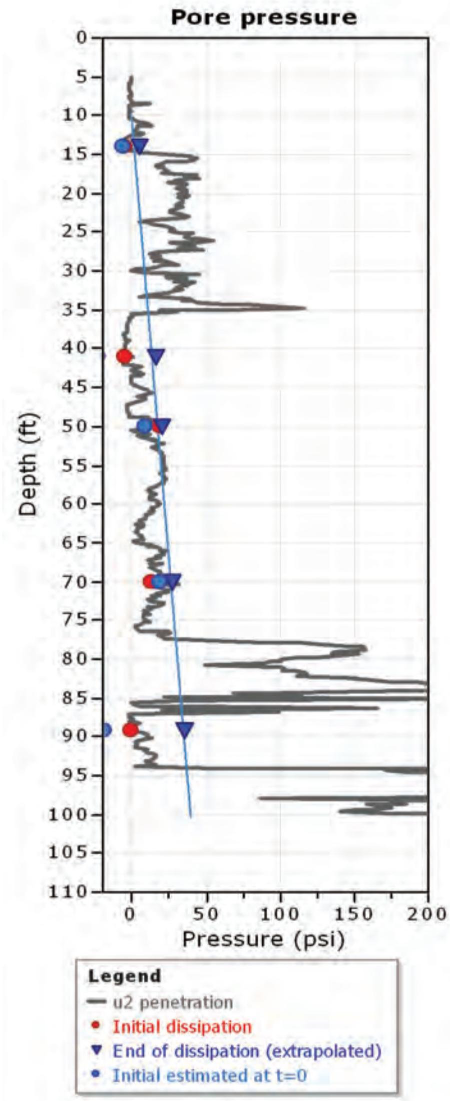

Piezocone Dissipation Test: 141cpi9
Depth: 14.11 (ft)
Porepressure u2 (psi)
t^0.50 (s^0.50)
u0 = 4.77 (psi)
u initial dissipation
assumed initial pore pressure, ui

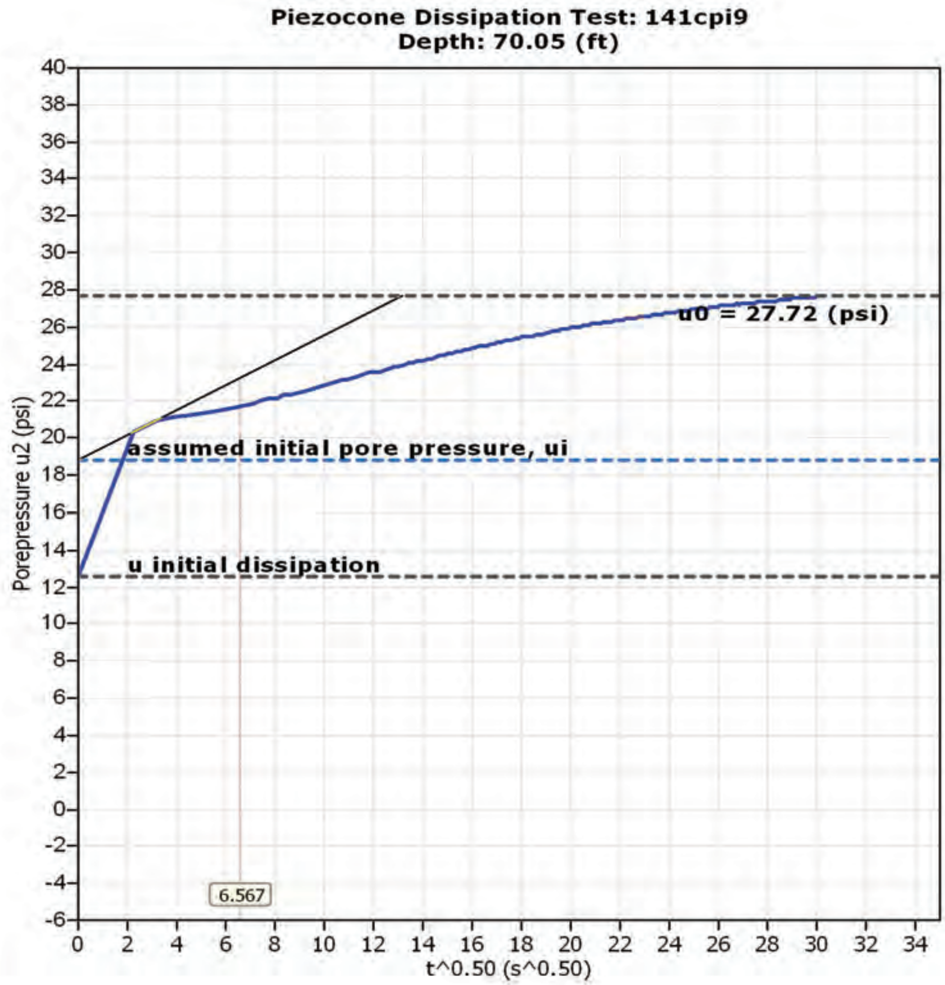

Pore pressure
Depth (ft)
Pressure (psi)
Legend
u2 penetration
Initial dissipation
End of dissipation (extrapolated)
Initial estimated at t=0


Piezocone Dissipation Test: 141cpi9
Depth: 41.01 (ft)
Porepressure u2 (psi)
t^0.50 (s^0.50)
u0 = 16.05 (psi)
u initial dissipation

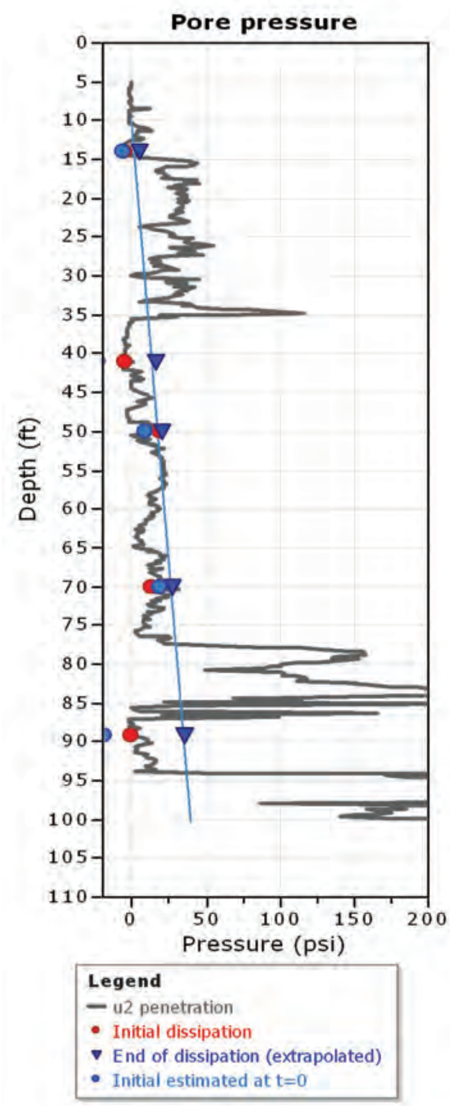

Pore pressure
Depth (ft)
Pressure (psi)
Legend
u2 penetration
Initial dissipation
End of dissipation (extrapolated)
Initial estimated at t=0


Piezocone Dissipation Test: 141cpi9
Depth: 50.03 (ft)
u initial dissipation
u0 = 20.04 (psi)
assumed initial pore pressure, ui
2.288
Porepressure u2 (psi)
t^0.50 (s^0.50)

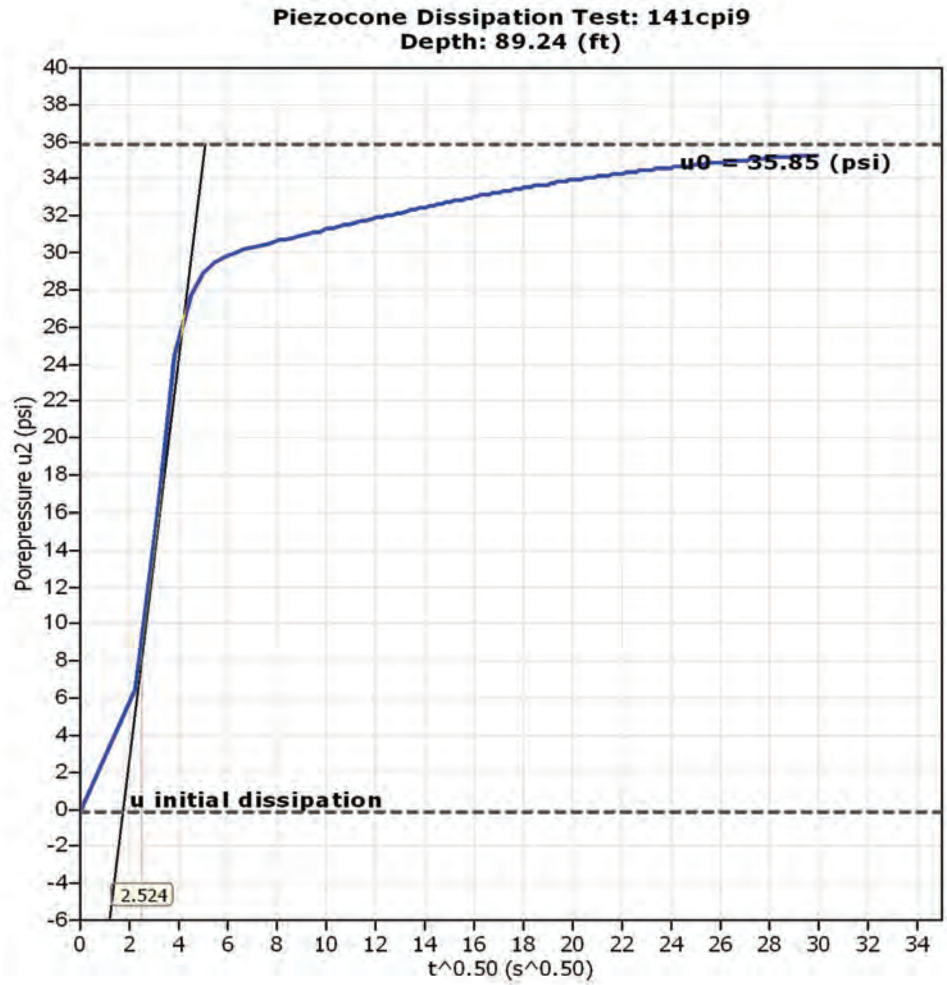

Pore pressure
Depth (ft)
Pressure (psi)
Legend
u2 penetration
Initial dissipation
End of dissipation (extrapolated)
Initial estimated at t=0



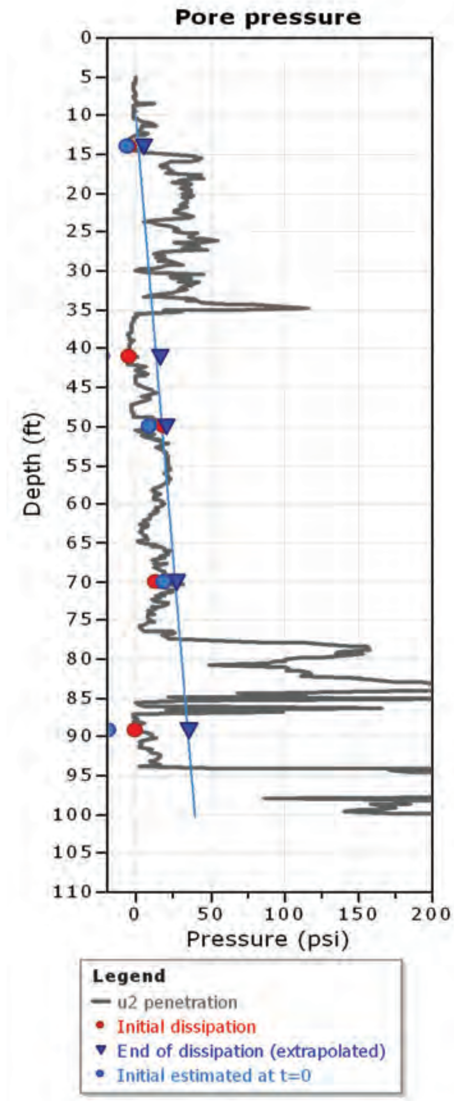
Piezocone Dissipation Test: 141cpi9
Depth: 70.05 (ft)
Porepressure u2 (psi)
t^0.50 (s^0.50)
u0 = 27.72 (psi)
assumed initial pore pressure, ui
u initial dissipation
6.567



Pore pressure
Depth (ft)
Pressure (psi)
Legend
u2 penetration
Initial dissipation
End of dissipation (extrapolated)
Initial estimated at t=0

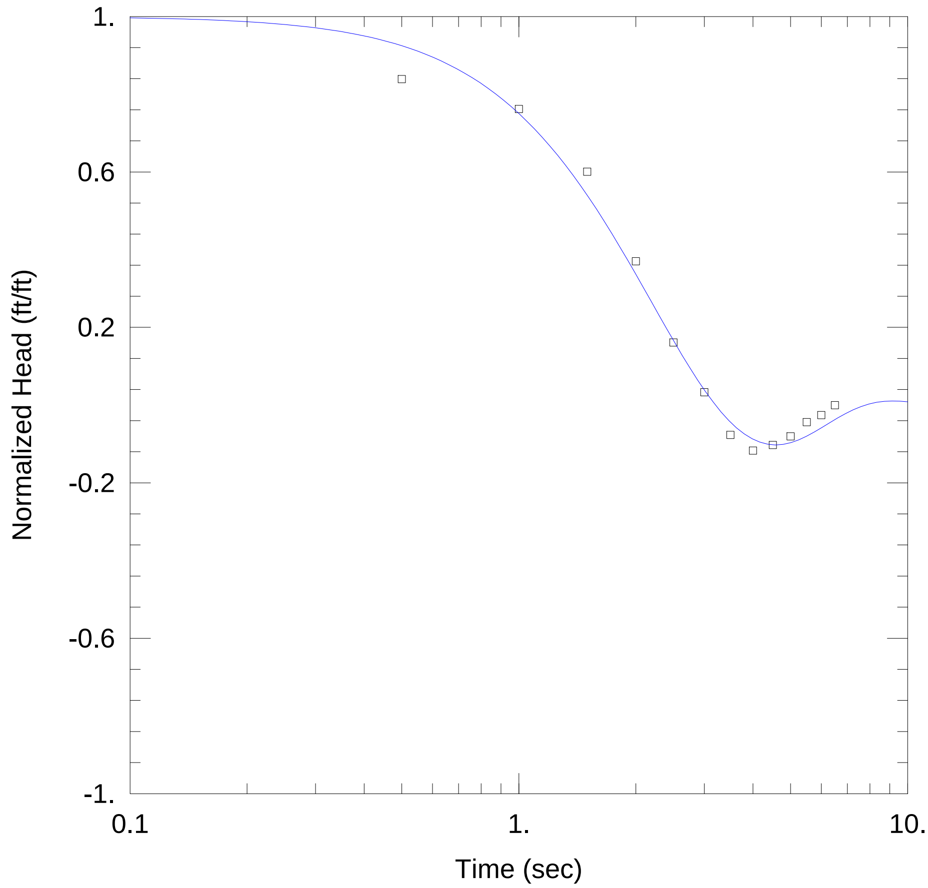


Piezocone Dissipation Test: 141cpi9
Depth: 89.24 (ft)
u0 = 35.85 (psi)
u initial dissipation
2.524
Porepressure u2 (psi)
t^0.50 (s^0.50)



Pore pressure
Depth (ft)
Pressure (psi)
Legend
u2 penetration
Initial dissipation
End of dissipation (extrapolated)
Initial estimated at t=0

Appendix F. Slug Testing Results



5 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\PI-1\Slug_PI_1B_5a(-1)confined.aqt
Date: 02/13/14 Time: 10:58:56

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: PI-1B
Test Date: 08/05/2013

AQUIFER DATA

Saturated Thickness: 22. ft
Anisotropy Ratio (Kz/Kr): 1.

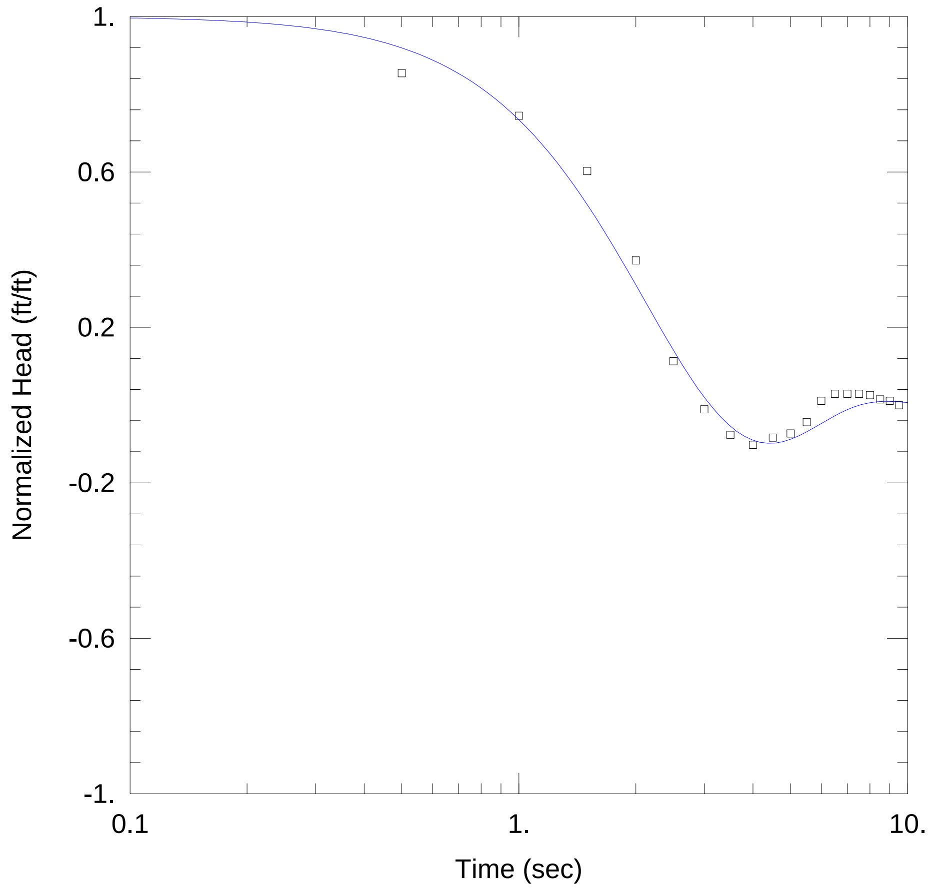
WELL DATA (PI-1B)

Initial Displacement: 0.273 ft
Total Well Penetration Depth: 19.1 ft
Casing Radius: 0.042 ft
Static Water Column Height: 0. ft
Screen Length: 10. ft
Well Radius: 0.042 ft

SOLUTION

Aquifer Model: Confined
Solution Method: McElwee-Zenner

K = 0.01063 cm/sec
A = 0.
ß = 44.71 ft
v(0) = 0. cm/sec



5 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\PI-1\Slug_PI_1B_5b(-1)confined.aqt
Date: 02/13/14 Time: 11:02:08

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: PI-1B
Test Date: 08/05/2013

AQUIFER DATA

Saturated Thickness: 22. ft Anisotropy Ratio (Kz/Kr): 1.

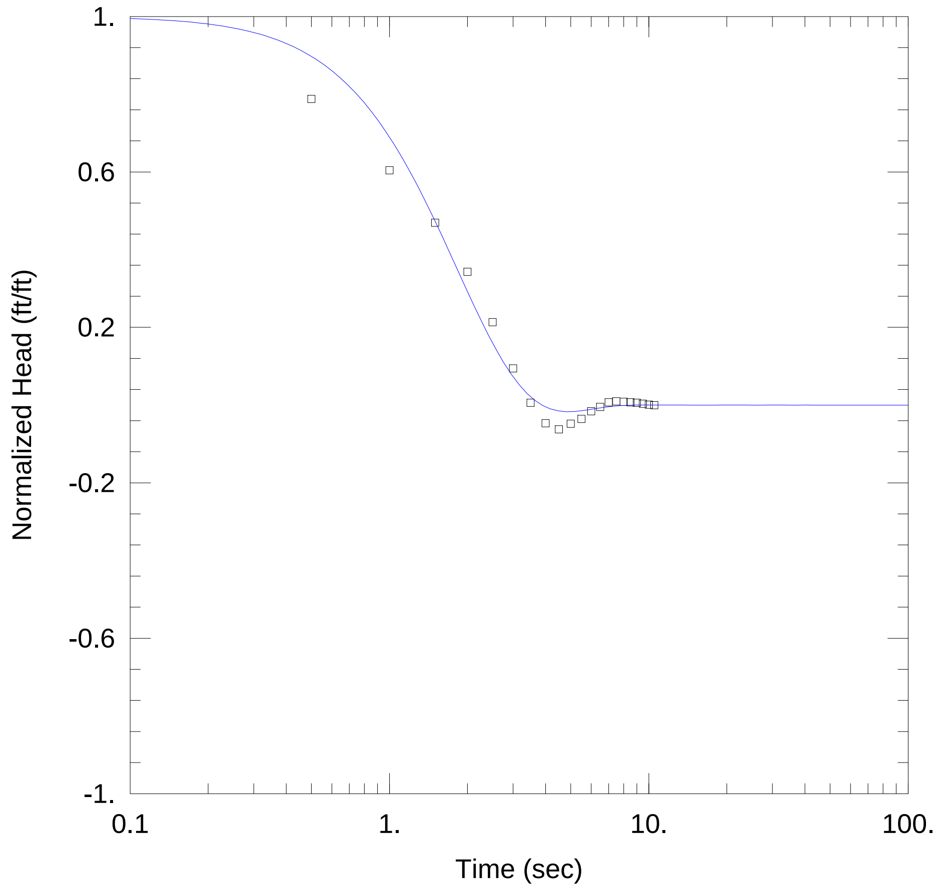
WELL DATA (PI-1B)

Initial Displacement: 0.274 ft
Total Well Penetration Depth: 19.1 ft
Casing Radius: 0.042 ft
Static Water Column Height: 0. ft
Screen Length: 10. ft
Well Radius: 0.042 ft

SOLUTION

Aquifer Model: Confined Solution Method: McElwee-Zenner

K = 0.01094 cm/sec
A = 0.
ß = 41.22 ft
v(0) = 0. cm/sec



10 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\PI-1\Slug_PI_1B_10a(-1)confined.aqt
Date: 02/13/14 Time: 11:03:38

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: PI-1B
Test Date: 08/05/2013

AQUIFER DATA

Saturated Thickness: 22. ft Anisotropy Ratio (Kz/Kr): 1.

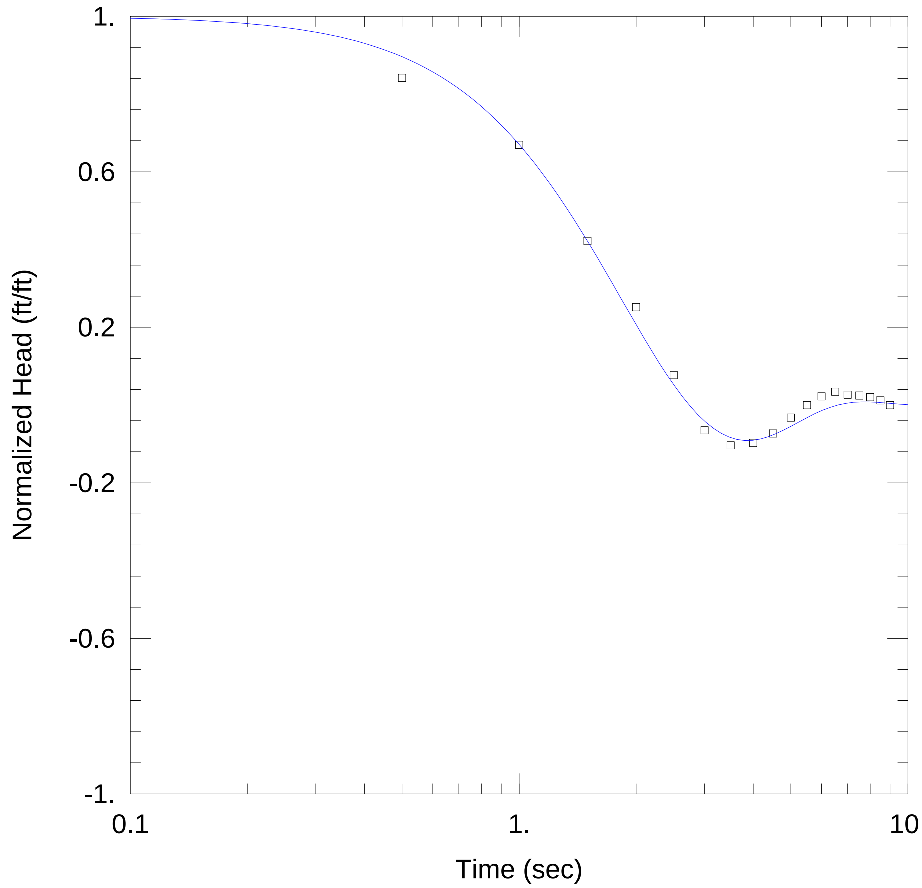
WELL DATA (PI-1B)

Initial Displacement: 0.816 ft
Total Well Penetration Depth: 19.1 ft
Casing Radius: 0.042 ft
Static Water Column Height: 0. ft
Screen Length: 10. ft
Well Radius: 0.042 ft

SOLUTION

Aquifer Model: Confined Solution Method: McElwee-Zenner

K = 0.009768 cm/sec
A = 0.
ß = 29.02 ft
v(0) = 0. cm/sec



10 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\PI-1\Slug_PI_1B_10b(-1)confined.aqt
Date: 02/13/14 Time: 11:07:37

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: PI-1B
Test Date: 08/05/2013

AQUIFER DATA

Saturated Thickness: 22. ft
Anisotropy Ratio (Kz/Kr): 1.

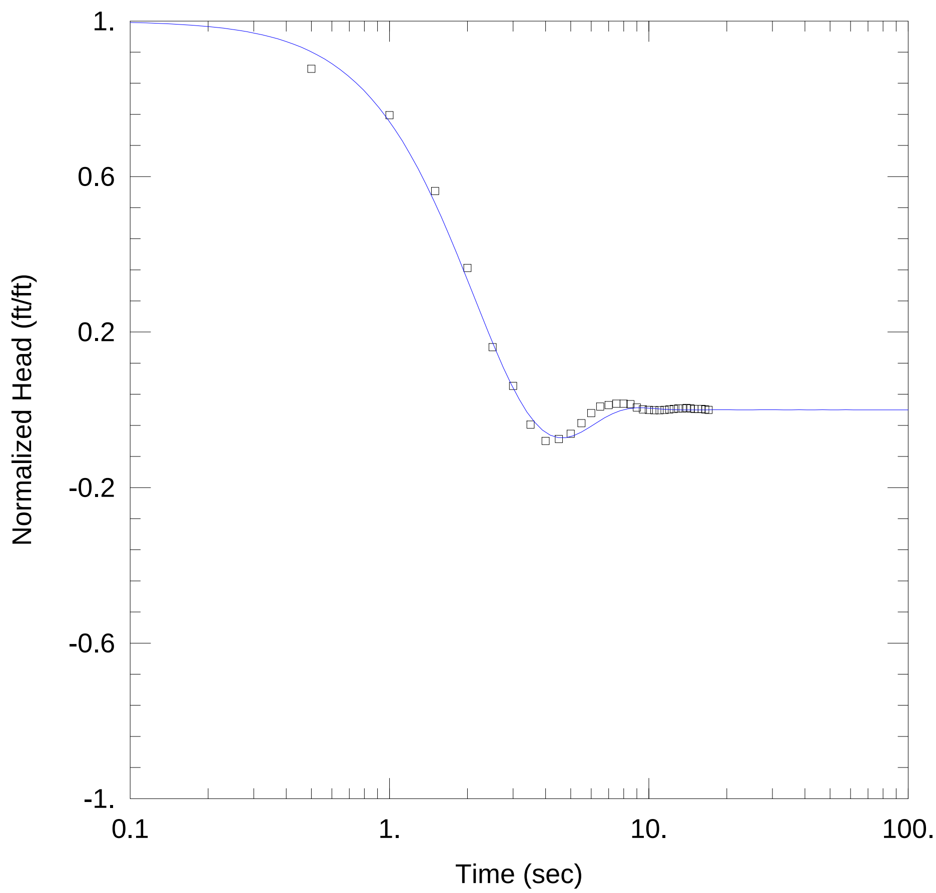
WELL DATA (PI-1B)

Initial Displacement: 0.493 ft
Total Well Penetration Depth: 19.1 ft
Casing Radius: 0.042 ft
Static Water Column Height: 0. ft
Screen Length: 10. ft
Well Radius: 0.042 ft

SOLUTION

Aquifer Model: Confined
Solution Method: McElwee-Zenner

K = 0.01241 cm/sec
A = 0.
ß = 30.75 ft
v(0) = 0. cm/sec



15 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\PI-1\Slug_PI_1B_15a(-1)confined.aqt
Date: 02/13/14 Time: 11:09:36

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: PI-1B
Test Date: 08/05/2013

AQUIFER DATA

Saturated Thickness: 22. ft
Anisotropy Ratio (Kz/Kr): 1.

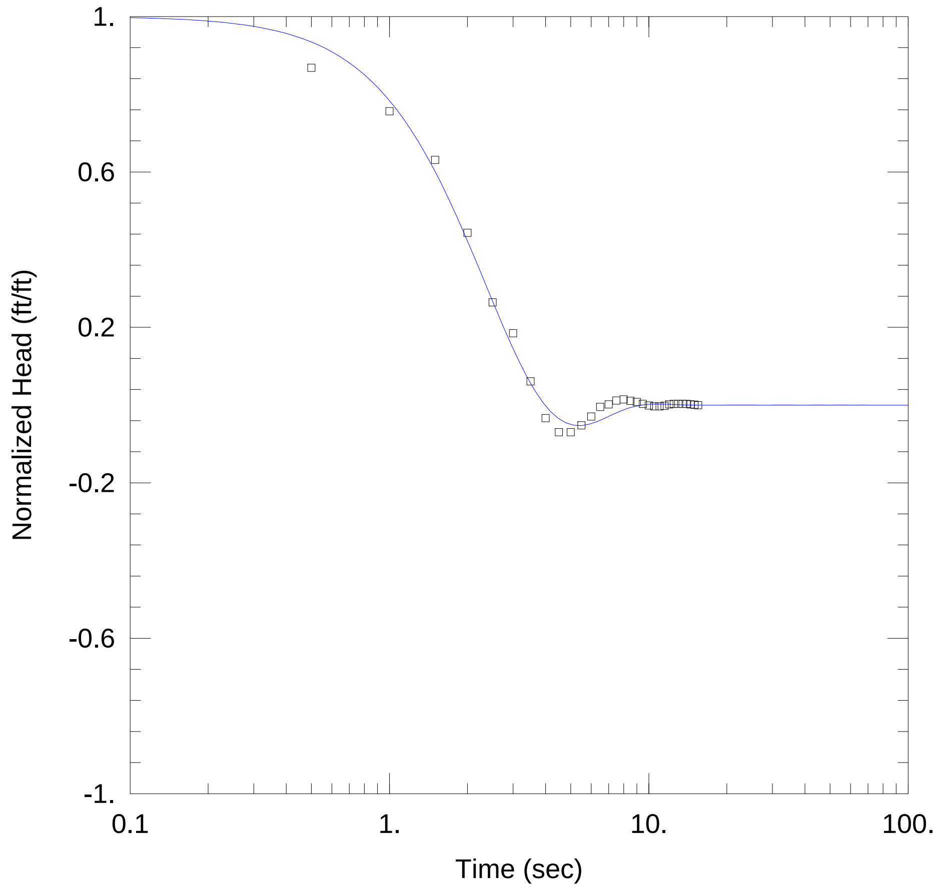
WELL DATA (PI-1B)

Initial Displacement: 0.814 ft
Total Well Penetration Depth: 19.1 ft
Casing Radius: 0.042 ft
Static Water Column Height: 0. ft
Screen Length: 10. ft
Well Radius: 0.042 ft

SOLUTION

Aquifer Model: Confined
Solution Method: McElwee-Zenner

K = 0.01016 cm/sec
A = 0.
ß = 41. ft
v(0) = 0. cm/sec



15 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\PI-1\Slug_PI_1B_15b(-1)confined.aqt
Date: 02/13/14 Time: 11:12:54

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: PI-1B
Test Date: 08/05/2013

AQUIFER DATA

Saturated Thickness: 22. ft
Anisotropy Ratio (Kz/Kr): 1.

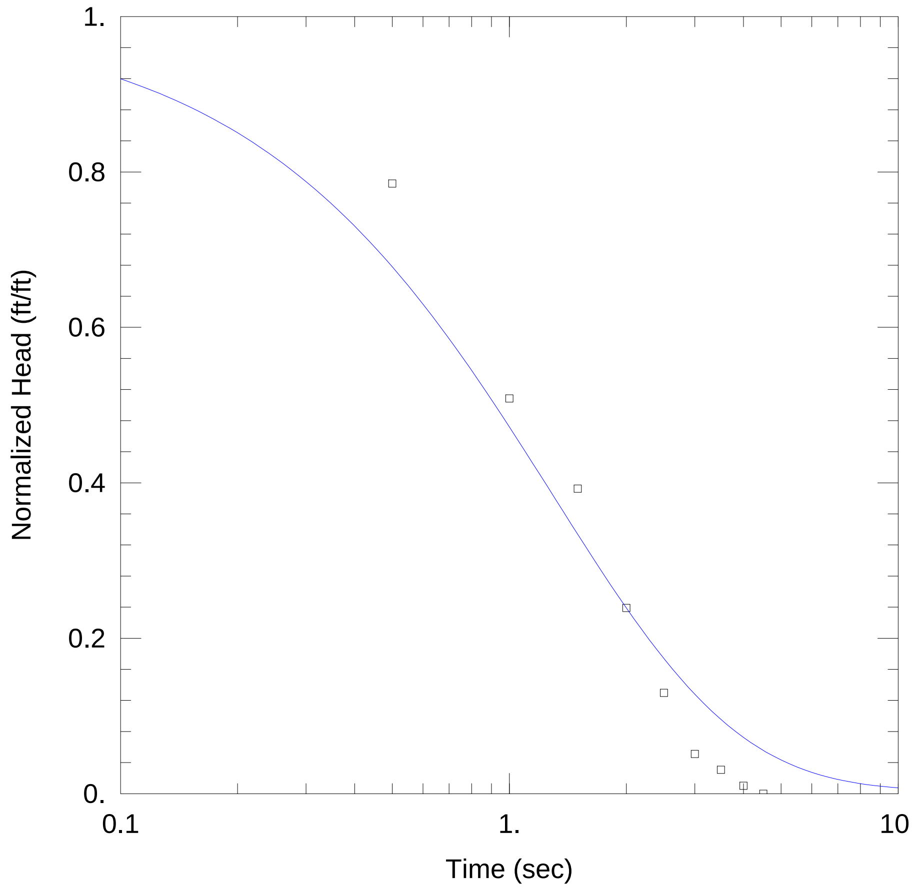
WELL DATA (PI-1B)

Initial Displacement: 1.017 ft
Total Well Penetration Depth: 19.1 ft
Casing Radius: 0.042 ft
Static Water Column Height: 0. ft
Screen Length: 10. ft
Well Radius: 0.042 ft

SOLUTION

Aquifer Model: Confined
Solution Method: McElwee-Zenner

K = 0.008631 cm/sec
A = 0.
ß = 50.04 ft
v(0) = 0. cm/sec



5 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\PI-2\Slug_PI_2B_5a(-1)confined.aqt
Date: 02/13/14 Time: 11:20:12

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: PI-2B
Test Date: 08/01/2013

AQUIFER DATA

Saturated Thickness: 11.49 ft

WELL DATA (PI-2B)

Initial Displacement: 0.293 ft
Total Well Penetration Depth: 10.18 ft
Casing Radius: 0.042 ft

Static Water Column Height: 0. ft
Screen Length: 10. ft
Well Radius: 0.042 ft
Gravel Pack Porosity: 0.

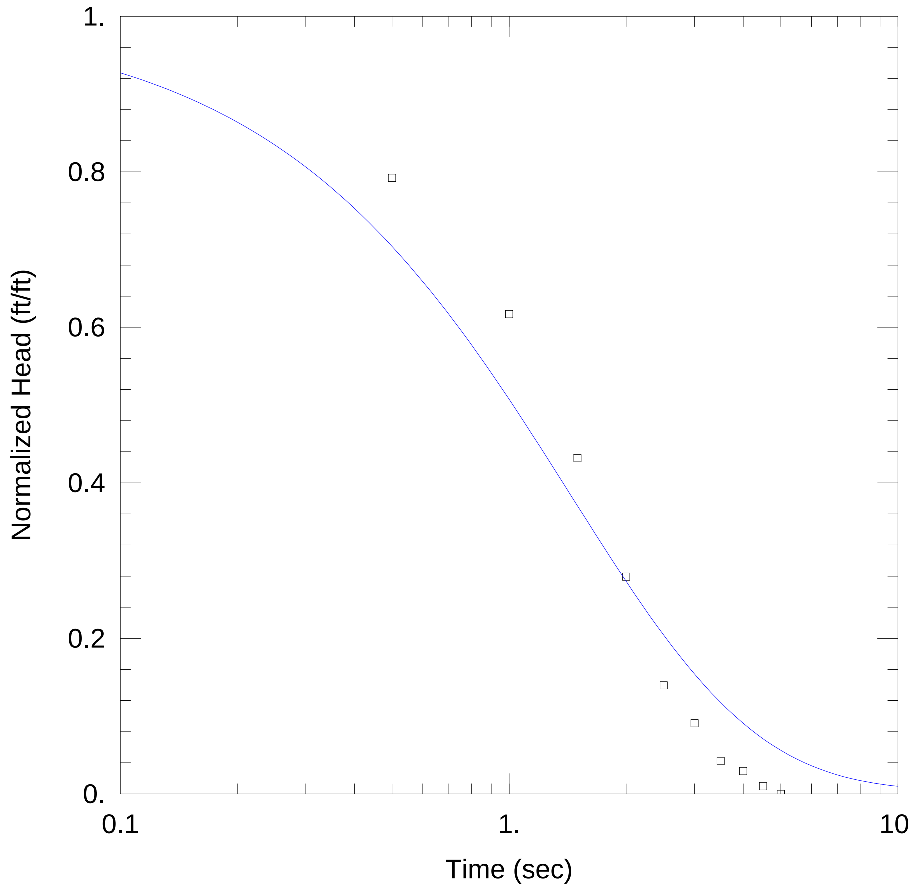
SOLUTION

Aquifer Model: Confined

Solution Method: KGS Model

Kr = 0.03272 cm/sec
Kz/Kr = 1.

Ss = 8.703E-12 ft^{-1}



5 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\PI-2\Slug_PI_2B_5b(-1)confined.aqt
Date: 02/13/14 Time: 11:46:21

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: PI-2B
Test Date: 08/01/2013

AQUIFER DATA

Saturated Thickness: 11.49 ft

WELL DATA (PI-2B)

Initial Displacement: 0.308 ft
Total Well Penetration Depth: 10.18 ft
Casing Radius: 0.042 ft

Static Water Column Height: 0. ft
Screen Length: 10. ft
Well Radius: 0.042 ft
Gravel Pack Porosity: 0.

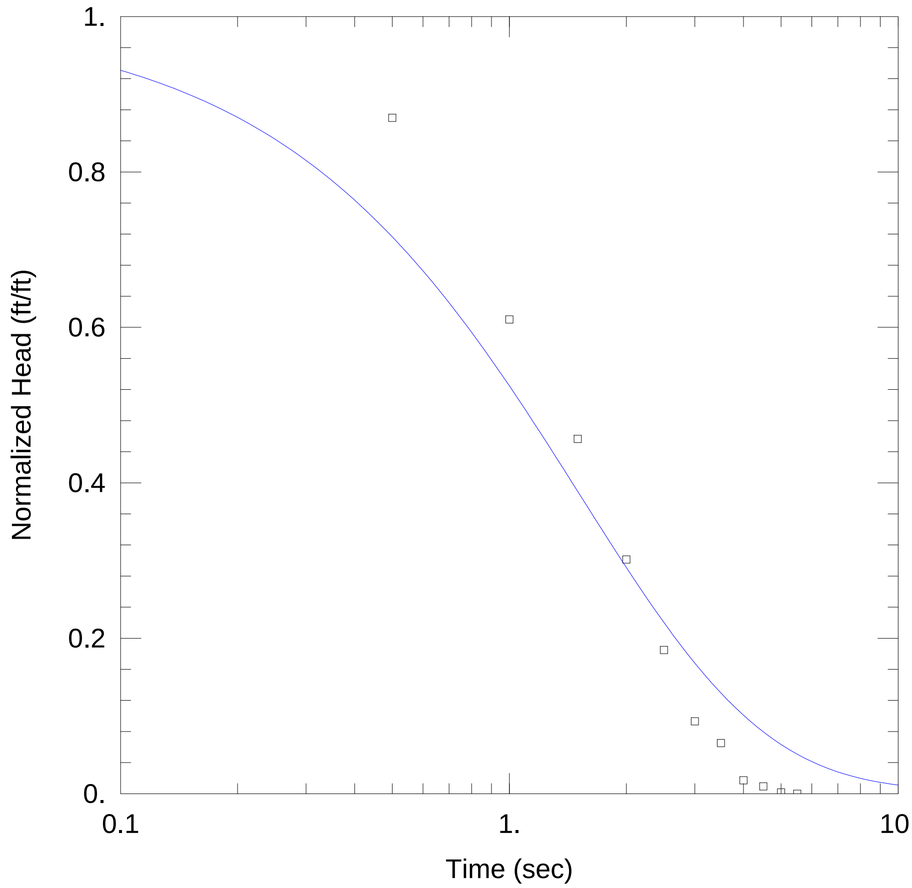
SOLUTION

Aquifer Model: Confined

Solution Method: KGS Model

Kr = 0.0279 cm/sec
Kz/Kr = 1.

Ss = 8.703E-12 ft^{-1}



10 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\PI-2\Slug_PI_2B_10a(-1)confined.aqt
Date: 02/13/14 Time: 11:49:57

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: PI-2B
Test Date: 08/01/2013

AQUIFER DATA

Saturated Thickness: 11.49 ft

WELL DATA (PI-2B)

Initial Displacement: 0.644 ft
Total Well Penetration Depth: 10.18 ft
Casing Radius: 0.042 ft

Static Water Column Height: 0. ft
Screen Length: 10. ft
Well Radius: 0.042 ft
Gravel Pack Porosity: 0.

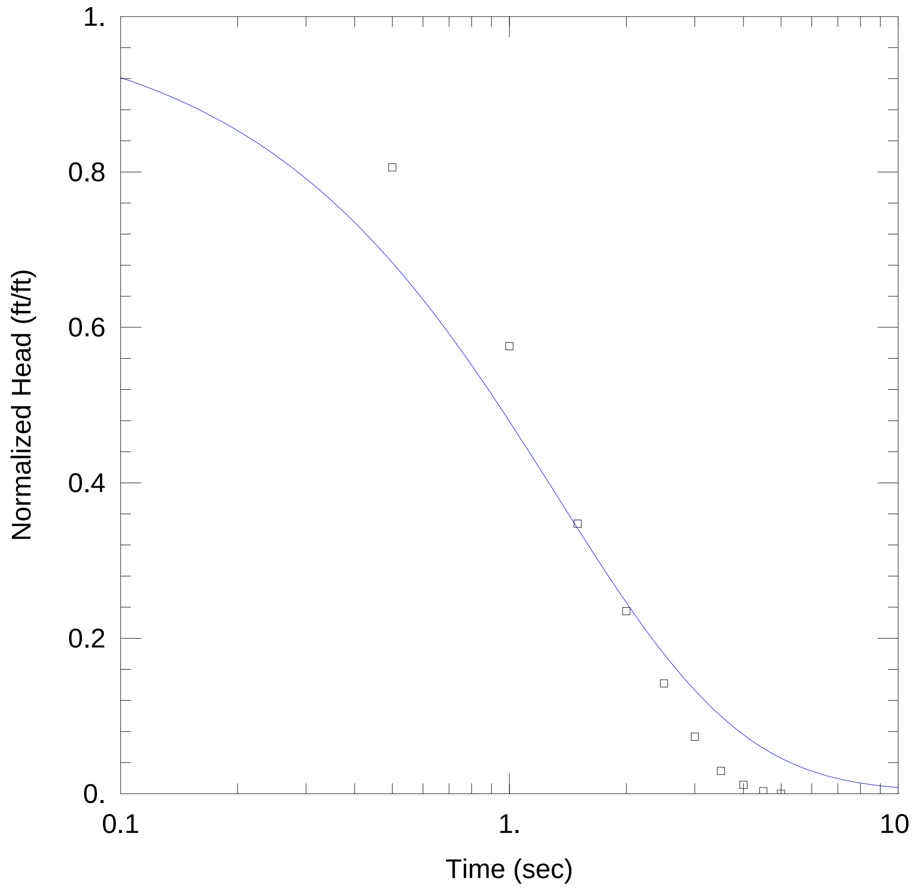
SOLUTION

Aquifer Model: Confined

Solution Method: KGS Model

Kr = 0.02522 cm/sec
Kz/Kr = 1.

Ss = 8.703E-12 ft^{-1}



10 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\PI-2\Slug_PI_2B_10b(-1)confined.aqt
Date: 02/13/14 Time: 11:51:42

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: PI-2B
Test Date: 08/01/2013

AQUIFER DATA

Saturated Thickness: 11.49 ft

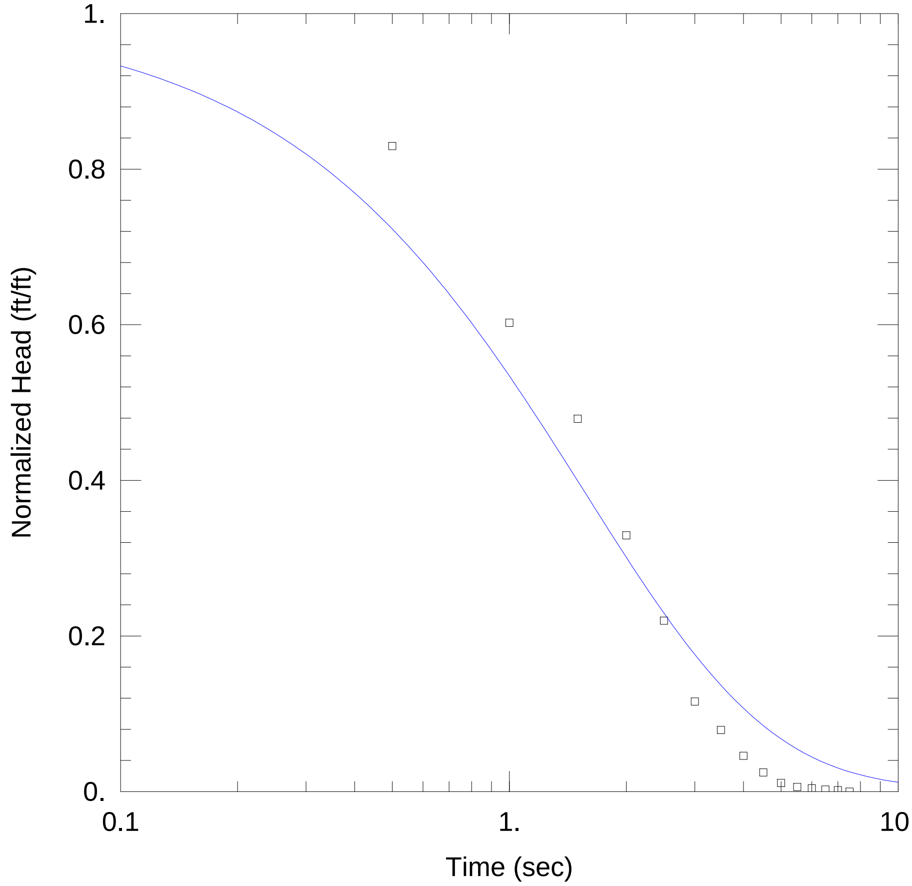
WELL DATA (PI-2B)

Initial Displacement: 0.613 ft
Total Well Penetration Depth: 10.18 ft
Casing Radius: 0.042 ft
Static Water Column Height: 0. ft
Screen Length: 10. ft
Well Radius: 0.042 ft
Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined
Solution Method: KGS Model

Kr = 0.03052 cm/sec
Kz/Kr = 1.
Ss = 8.703E-12 ft^{-1}



15 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\PI-2\Slug_PI_2B_15a(-1)confined.aqt
Date: 02/13/14 Time: 11:53:46

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: PI-2B
Test Date: 08/01/2013

AQUIFER DATA

Saturated Thickness: 11.49 ft

WELL DATA (PI-2B)

Initial Displacement: 1.175 ft
Total Well Penetration Depth: 10.18 ft
Casing Radius: 0.042 ft

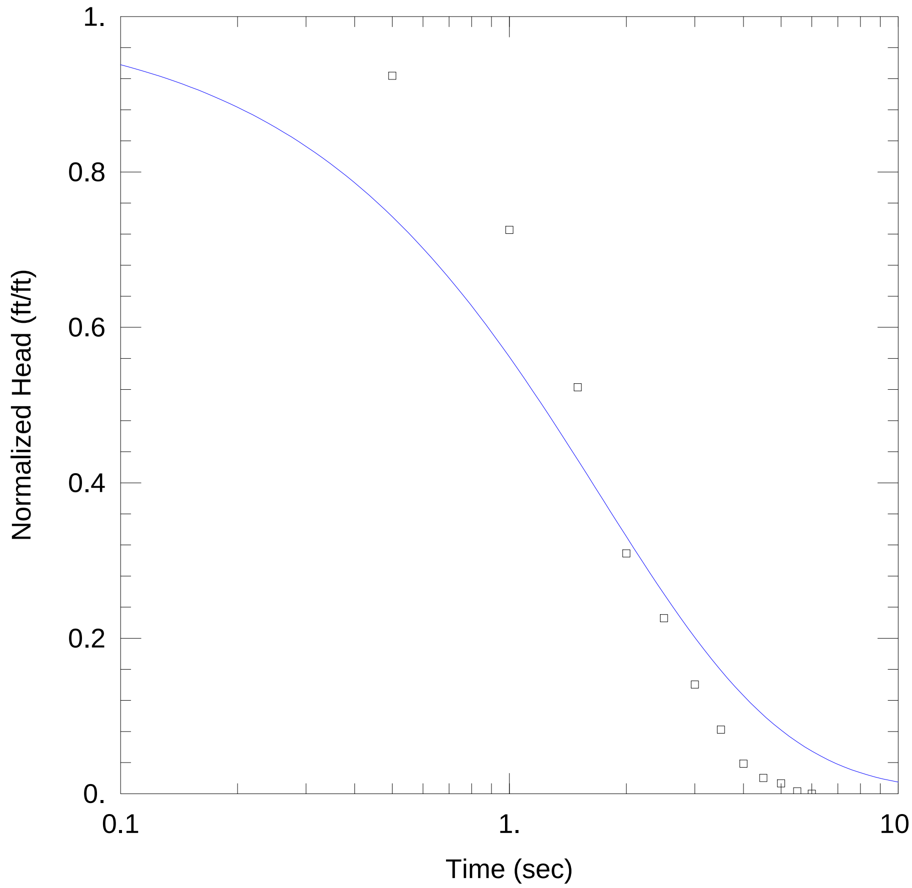
Static Water Column Height: 0. ft
Screen Length: 10. ft
Well Radius: 0.042 ft
Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined
Solution Method: KGS Model

Kr = 0.01998 cm/sec
Kz/Kr = 1.

Ss = 8.703E-12 ft^{-1}



15 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\PI-2\Slug_PI_2B_15b(-1)confined.aqt
Date: 02/13/14 Time: 11:55:45

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: PI-2B
Test Date: 08/01/2013

AQUIFER DATA

Saturated Thickness: 11.49 ft

WELL DATA (PI-2B)

Initial Displacement: 0.983 ft
Total Well Penetration Depth: 10.18 ft
Casing Radius: 0.042 ft

Static Water Column Height: 0. ft
Screen Length: 10. ft
Well Radius: 0.042 ft
Gravel Pack Porosity: 0.

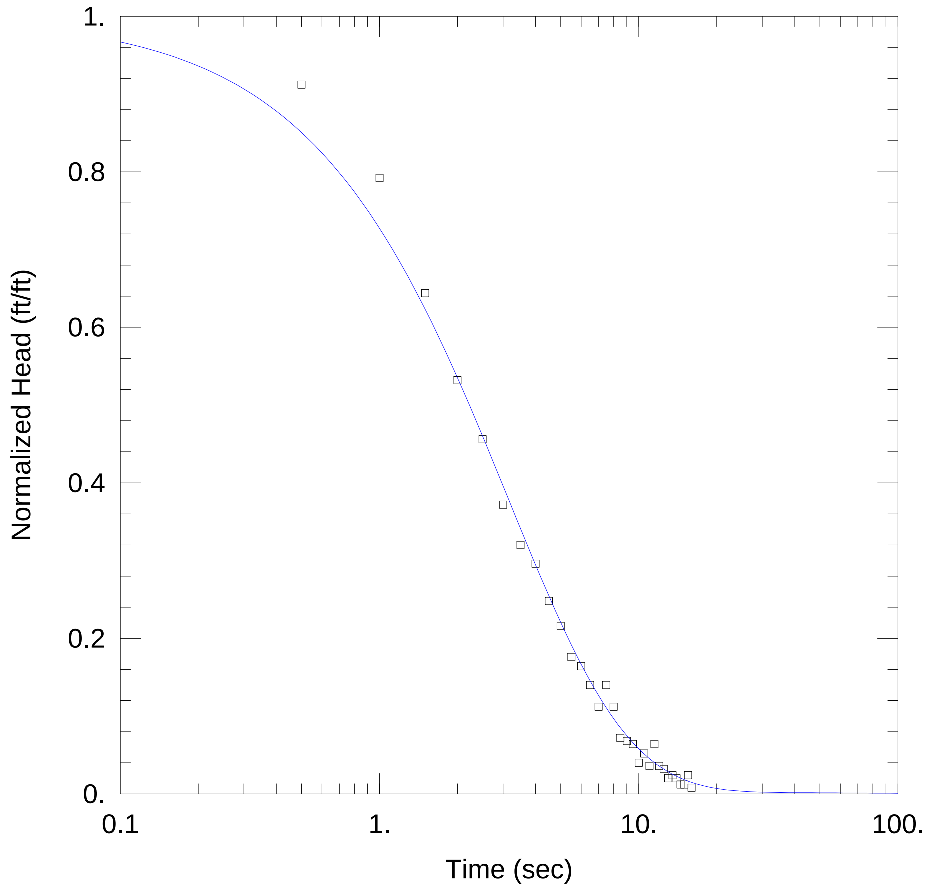
SOLUTION

Aquifer Model: Confined

Solution Method: KGS Model

Kr = 0.02201 cm/sec
Kz/Kr = 1.

Ss = 8.703E-12 ft^{-1}



3 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\PI-3\Slug_PI_3B_3a(-1)confined.aqt
Date: 02/13/14 Time: 11:59:58

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: PI-3B
Test Date: 07/31/2013

AQUIFER DATA

Saturated Thickness: 35. ft

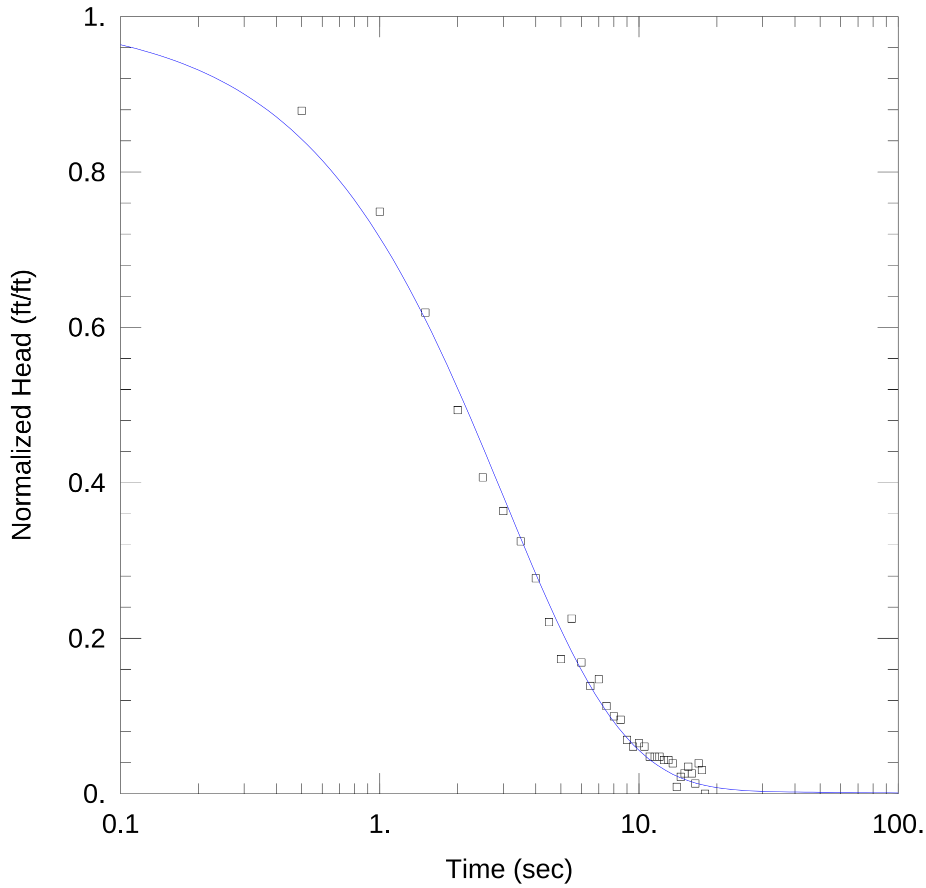
WELL DATA (PI-3B)

Initial Displacement: 0.25 ft
Total Well Penetration Depth: 15. ft
Casing Radius: 0.042 ft
Static Water Column Height: 0. ft
Screen Length: 10. ft
Well Radius: 0.042 ft

SOLUTION

Aquifer Model: Confined
Solution Method: KGS Model

Kr = 0.005794 cm/sec
Kz/Kr = 1.
Ss = 2.857E-12 ft^{-1}



3 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\PI-3\Slug_PI_3B_3b(-1)confined.aqt
Date: 02/13/14 Time: 12:02:11

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: PI-3B
Test Date: 07/31/2013

AQUIFER DATA

Saturated Thickness: 35. ft

WELL DATA (PI-3B)

Initial Displacement: 0.1925 ft
Total Well Penetration Depth: 15. ft
Casing Radius: 0.042 ft

Static Water Column Height: 0. ft
Screen Length: 10. ft
Well Radius: 0.042 ft
Gravel Pack Porosity: 0.

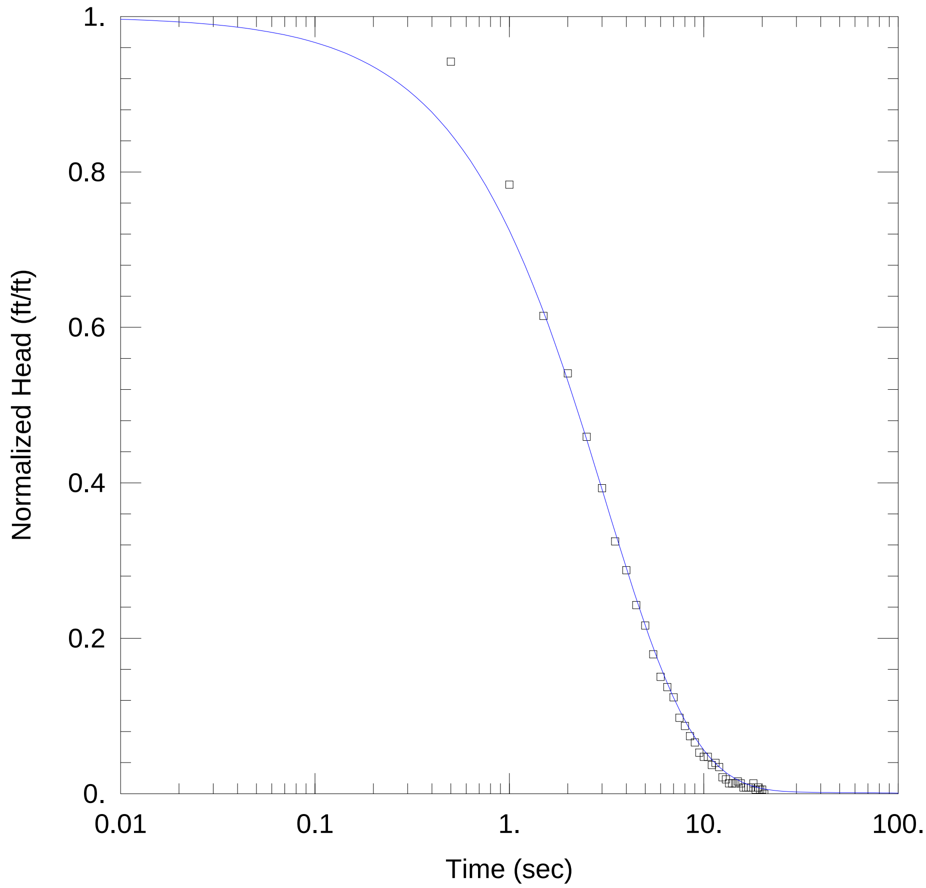
SOLUTION

Aquifer Model: Confined

Solution Method: KGS Model

Kr = 0.005973 cm/sec
Kz/Kr = 1.

Ss = 2.951E-7 ft^{-1}



6 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\PI-3\Slug_PI_3B_6a(-1)confined.aqt
Date: 02/13/14 Time: 16:50:05

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: PI-3B
Test Date: 07/31/2013

AQUIFER DATA

Saturated Thickness: 35. ft

WELL DATA (PI-3B)

Initial Displacement: 0.379 ft
Total Well Penetration Depth: 15. ft
Casing Radius: 0.042 ft

Static Water Column Height: 0. ft
Screen Length: 10. ft
Well Radius: 0.042 ft
Gravel Pack Porosity: 0.

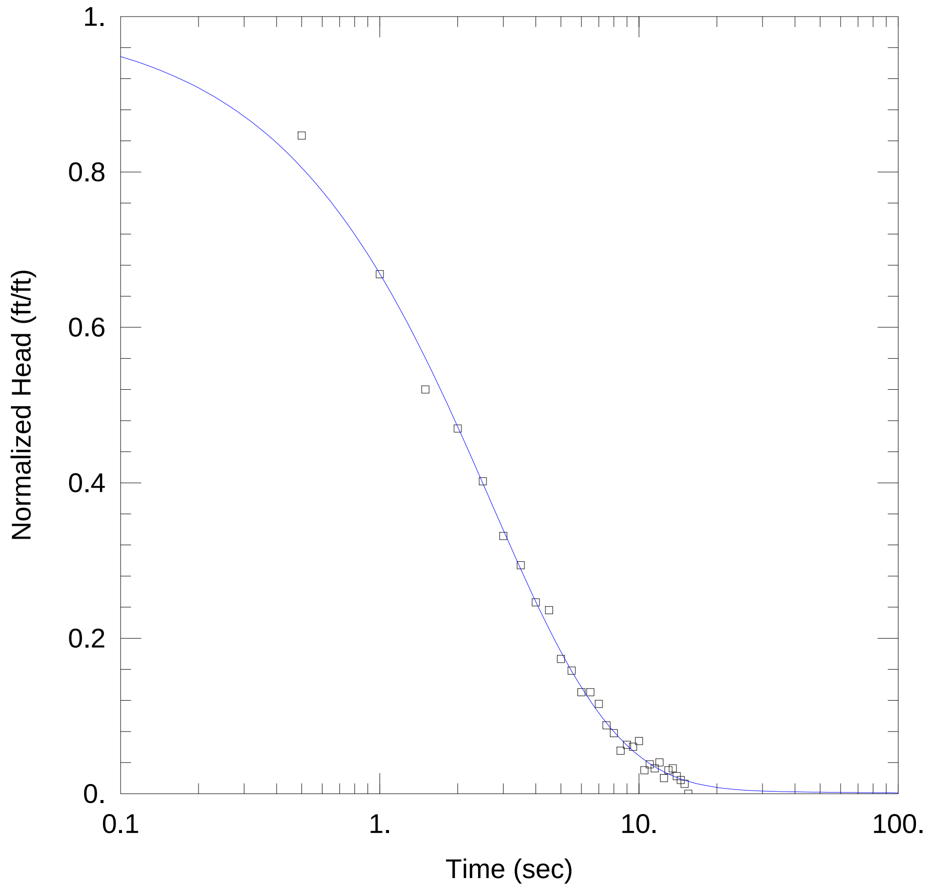
SOLUTION

Aquifer Model: Confined

Kr = 0.007786 cm/sec
Kz/Kr = 1.

Solution Method: KGS Model

Ss = 2.857E-12 ft^{-1}



6 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\PI-3\Slug_PI_3B_6b(-1)confined.aqt
Date: 02/13/14 Time: 16:53:33

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: PI-3B
Test Date: 07/31/2013

AQUIFER DATA

Saturated Thickness: 35. ft

WELL DATA (PI-3B)

Initial Displacement: 0.3317 ft
Total Well Penetration Depth: 15. ft
Casing Radius: 0.042 ft

Static Water Column Height: 0. ft
Screen Length: 10. ft
Well Radius: 0.042 ft
Gravel Pack Porosity: 0.

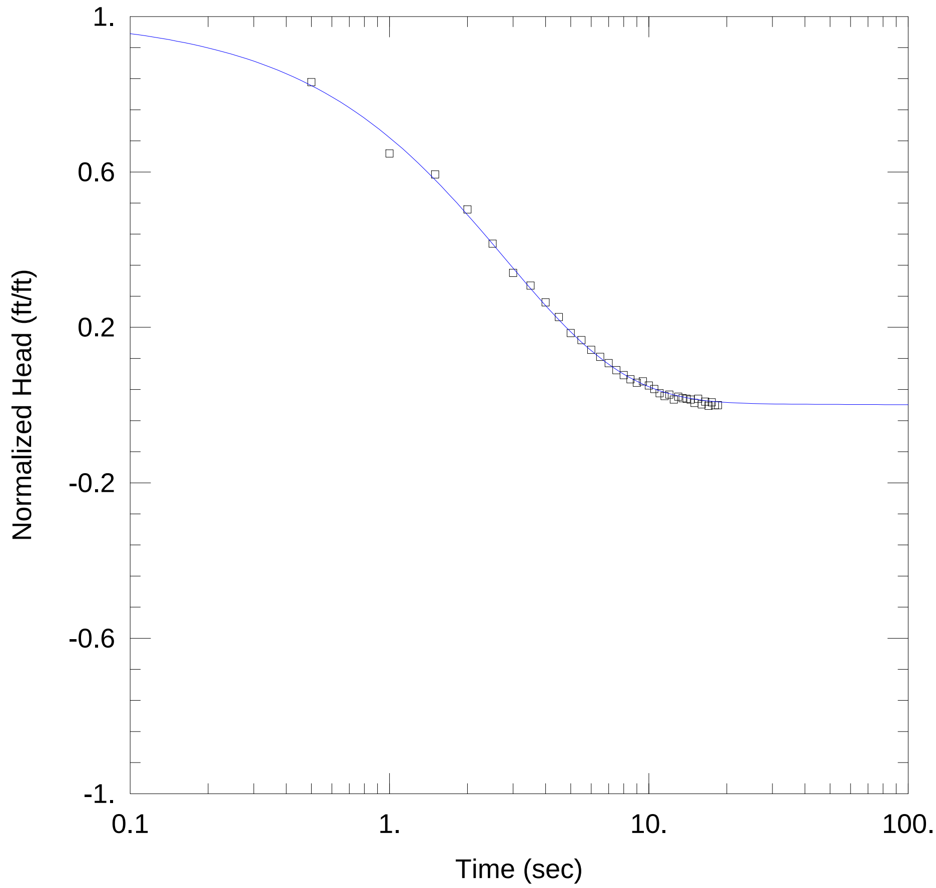
SOLUTION

Aquifer Model: Confined

Solution Method: KGS Model

Kr = 0.006857 cm/sec
Kz/Kr = 1.

Ss = 1.7E-5 ft^{-1}



9 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\PI-3\Slug_PI_3B_9a(-1)confined.aqt
Date: 02/13/14 Time: 12:07:58

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: PI-3B
Test Date: 07/31/2013

AQUIFER DATA

Saturated Thickness: 35. ft

WELL DATA (PI-3B)

Initial Displacement: 0.556 ft
Total Well Penetration Depth: 15. ft
Casing Radius: 0.042 ft

Static Water Column Height: 0. ft
Screen Length: 10. ft
Well Radius: 0.042 ft
Gravel Pack Porosity: 0.

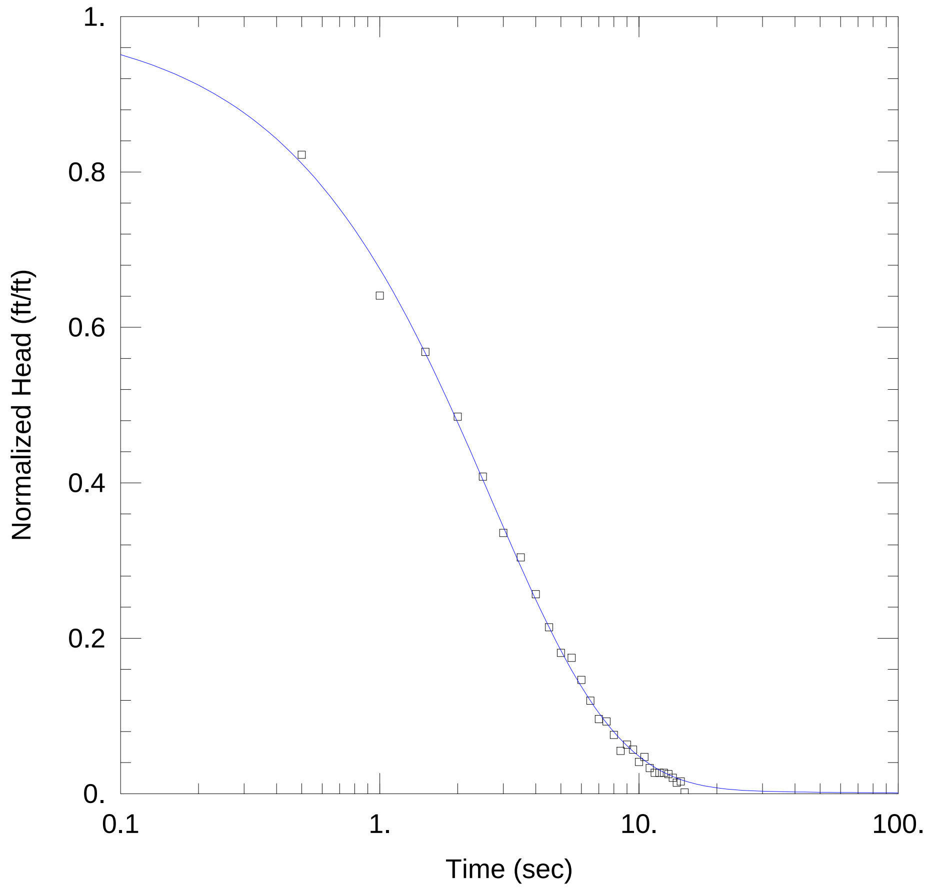
SOLUTION

Aquifer Model: Confined

Solution Method: KGS Model

Kr = 0.006302 cm/sec
Kz/Kr = 1.

Ss = 3.276E-6 ft^{-1}



9 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\PI-3\Slug_PI_3B_9b(-1)confined.aqt
Date: 02/13/14 Time: 12:09:33

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: PI-3B
Test Date: 07/31/2013

AQUIFER DATA

Saturated Thickness: 35. ft

WELL DATA (PI-3B)

Initial Displacement: 0.5292 ft
Total Well Penetration Depth: 15. ft
Casing Radius: 0.042 ft

Static Water Column Height: 0. ft
Screen Length: 10. ft
Well Radius: 0.042 ft
Gravel Pack Porosity: 0.

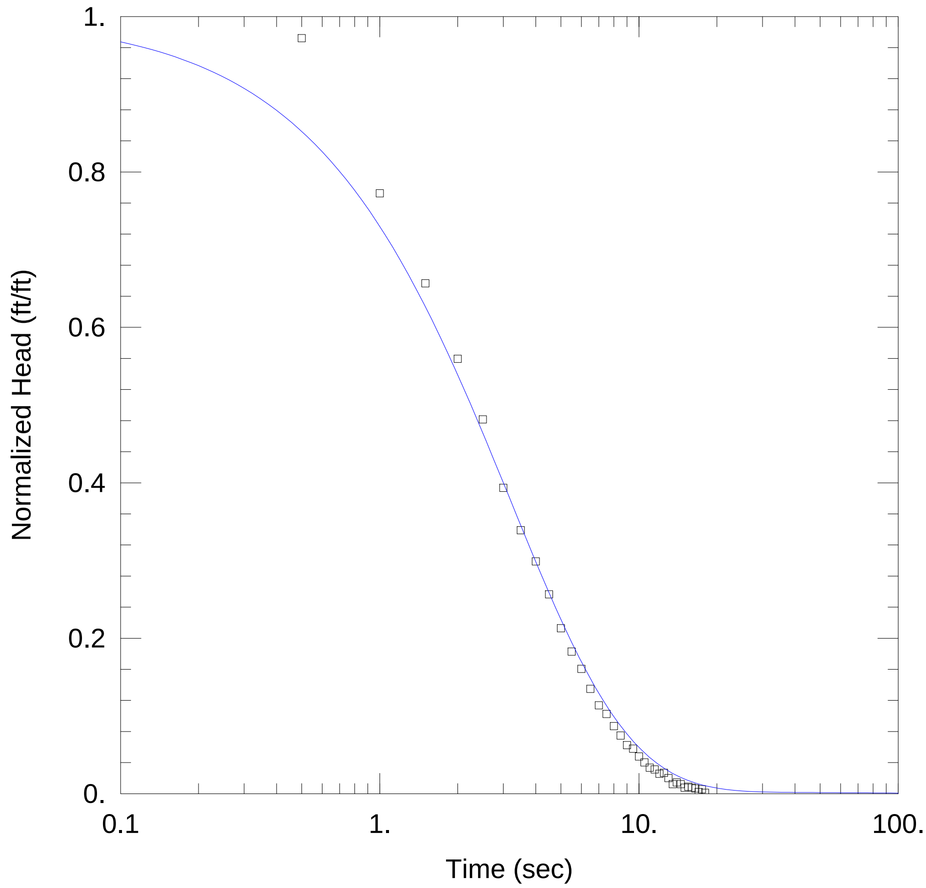
SOLUTION

Aquifer Model: Confined

Solution Method: KGS Model

Kr = 0.006506 cm/sec
Kz/Kr = 1.

Ss = 1.041E-5 ft^{-1}



12 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\PI-3\Slug_PI_3B_12a(-1)confined.aqt
Date: 02/13/14 Time: 12:10:33

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: PI-3B
Test Date: 07/31/2013

AQUIFER DATA

Saturated Thickness: 35. ft

WELL DATA (PI-3B)

Initial Displacement: 0.7475 ft
Total Well Penetration Depth: 15. ft
Casing Radius: 0.042 ft

Static Water Column Height: 0. ft
Screen Length: 10. ft
Well Radius: 0.042 ft
Gravel Pack Porosity: 0.

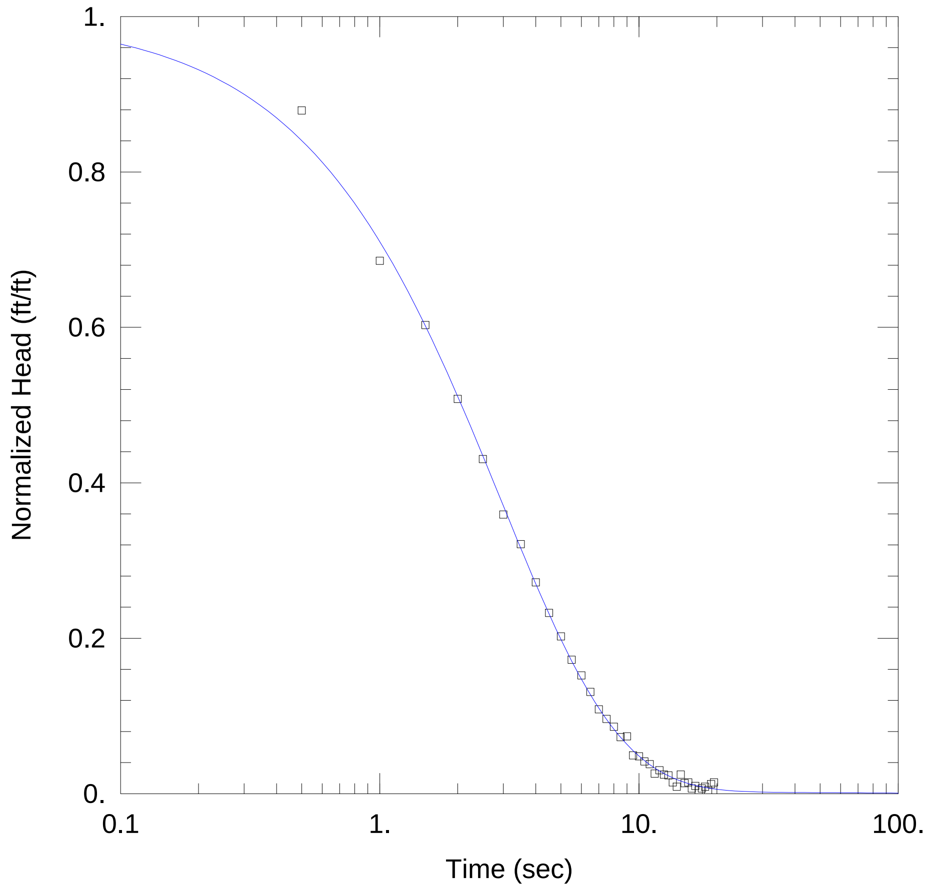
SOLUTION

Aquifer Model: Confined

Solution Method: KGS Model

Kr = 0.007712 cm/sec
Kz/Kr = 1.

Ss = 2.857E-12 ft^{-1}



12 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\PI-3\Slug_PI_3B_12b(-1)confined.aqt
Date: 02/13/14 Time: 12:11:45

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: PI-3B
Test Date: 07/31/2013

AQUIFER DATA

Saturated Thickness: 35. ft

WELL DATA (PI-3B)

Initial Displacement: 0.745 ft
Total Well Penetration Depth: 15. ft
Casing Radius: 0.042 ft

Static Water Column Height: 0. ft
Screen Length: 10. ft
Well Radius: 0.042 ft
Gravel Pack Porosity: 0.

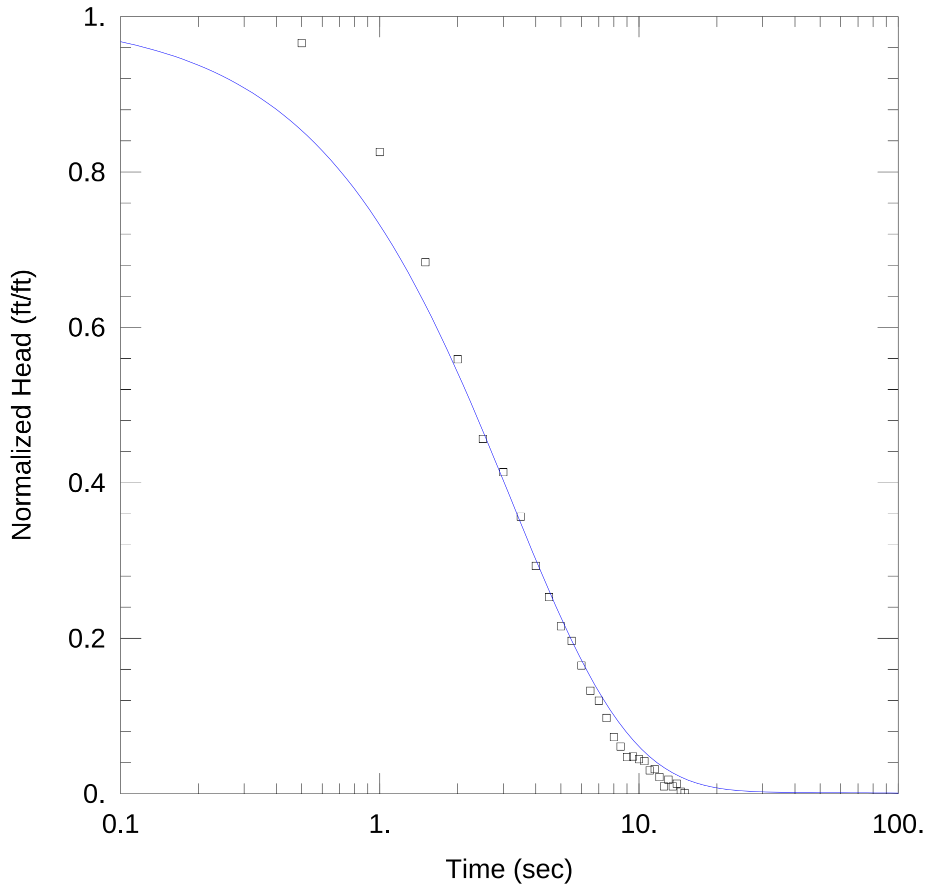
SOLUTION

Aquifer Model: Confined

Solution Method: KGS Model

Kr = 0.008144 cm/sec
Kz/Kr = 1.

Ss = 1.335E-11 ft^{-1}



15 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\PI-3\Slug_PI_3B_15a(-1)confined.aqt
Date: 02/13/14 Time: 12:12:52

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: PI-3B
Test Date: 07/31/2013

AQUIFER DATA

Saturated Thickness: 35. ft

WELL DATA (PI-3B)

Initial Displacement: 0.975 ft
Total Well Penetration Depth: 15. ft
Casing Radius: 0.042 ft

Static Water Column Height: 0. ft
Screen Length: 10. ft
Well Radius: 0.042 ft
Gravel Pack Porosity: 0.

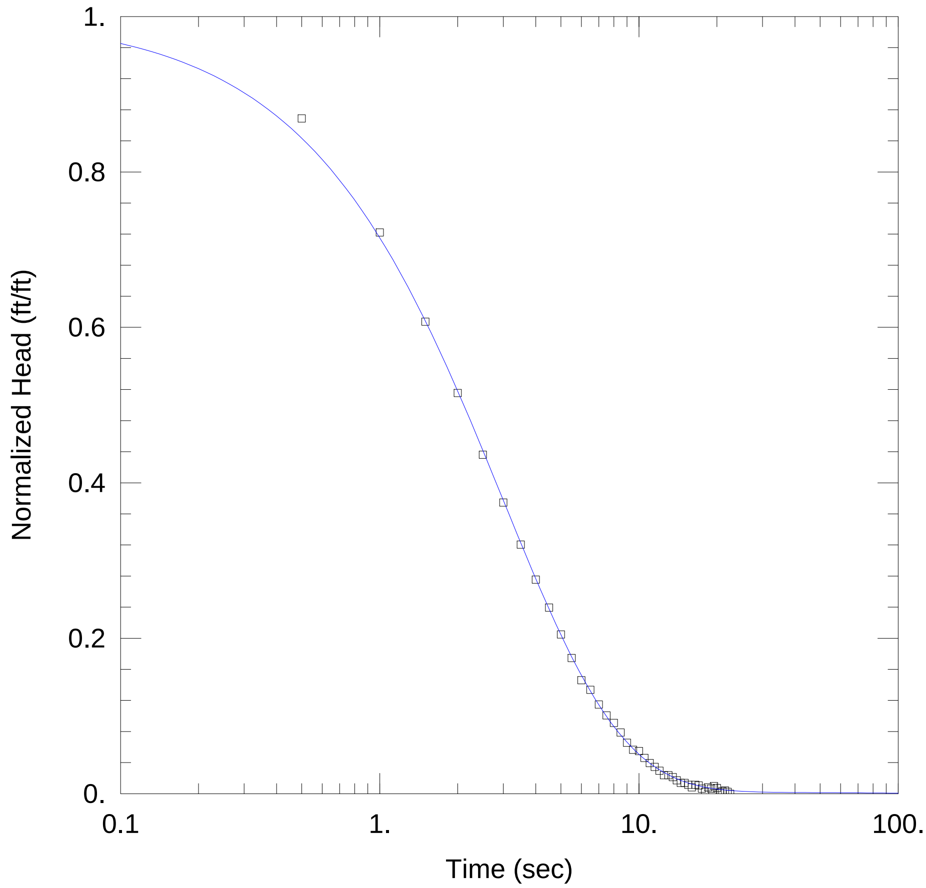
SOLUTION

Aquifer Model: Confined

Solution Method: KGS Model

Kr = 0.007323 cm/sec
Kz/Kr = 1.

Ss = 2.857E-12 ft^{-1}



15 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\PI-3\Slug_PI_3B_15b(-1)confined.aqt
Date: 02/13/14 Time: 12:13:56

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: PI-3B
Test Date: 07/31/2013

AQUIFER DATA

Saturated Thickness: 35. ft

WELL DATA (PI-3B)

Initial Displacement: 1.017 ft
Total Well Penetration Depth: 15. ft
Casing Radius: 0.042 ft

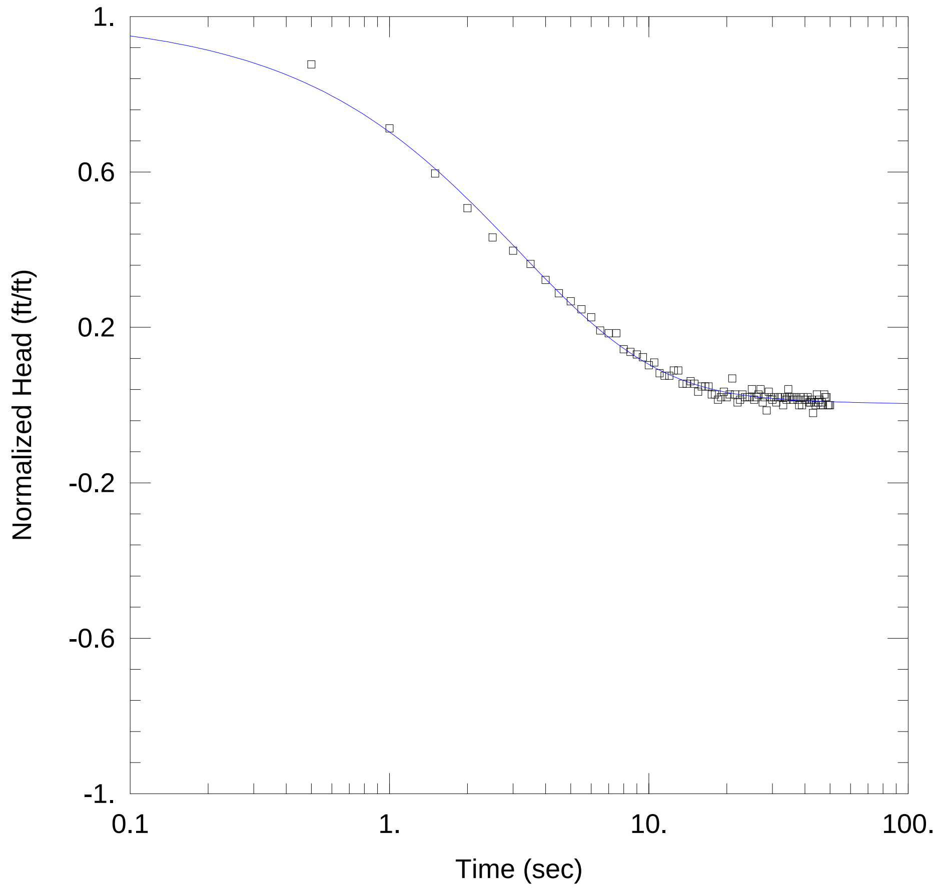
Static Water Column Height: 0. ft
Screen Length: 10. ft
Well Radius: 0.042 ft
Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined
Solution Method: KGS Model

Kr = 0.00754 cm/sec
Kz/Kr = 1.

Ss = 2.857E-12 ft^{-1}



3 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\PI-3\Slug_PI_3C_3a(-1)confined.aqt
Date: 02/13/14 Time: 16:57:48

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: PI-3C
Test Date: 07/31/2013

AQUIFER DATA

Saturated Thickness: 10. ft

WELL DATA (PI-3C)

Initial Displacement: 0.146 ft
Total Well Penetration Depth: 10. ft
Casing Radius: 0.042 ft

Static Water Column Height: 0. ft
Screen Length: 10. ft
Well Radius: 0.042 ft
Gravel Pack Porosity: 0.

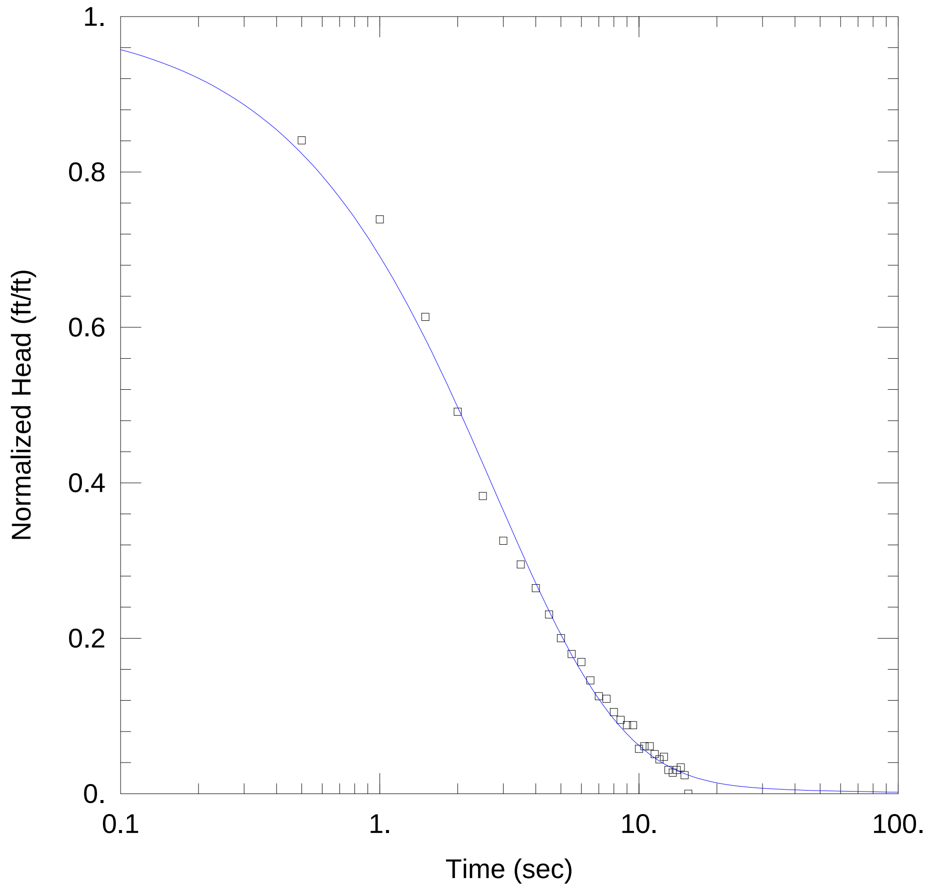
SOLUTION

Aquifer Model: Confined

Solution Method: KGS Model

Kr = 0.006224 cm/sec
Kz/Kr = 1.

Ss = 6.075E-5 ft^{-1}



3 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\PI-3\Slug_PI_3C_3b(-1)confined.aqt
Date: 02/13/14 Time: 17:15:51

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: PI-3C
Test Date: 07/31/2013

AQUIFER DATA

Saturated Thickness: 10. ft

WELL DATA (PI-3C)

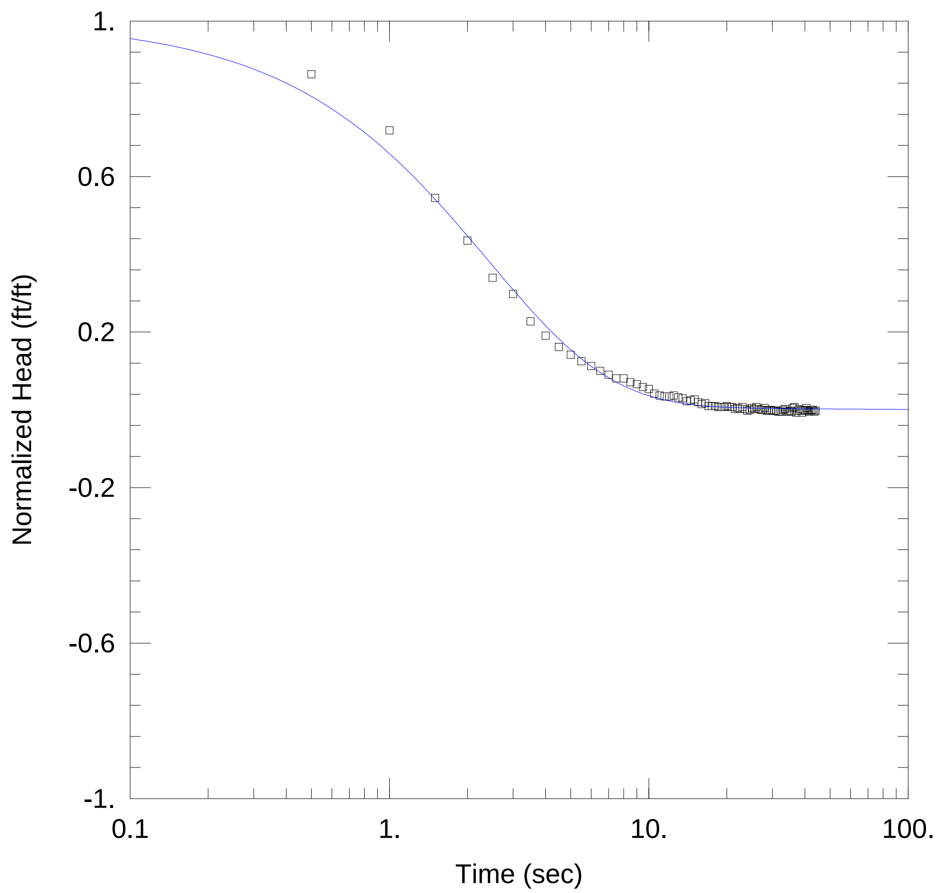
Initial Displacement: 0.2458 ft
Total Well Penetration Depth: 10. ft
Casing Radius: 0.042 ft

Static Water Column Height: 0. ft
Screen Length: 10. ft
Well Radius: 0.042 ft

SOLUTION

Aquifer Model: Confined
Solution Method: KGS Model

Kr = 0.007959 cm/sec
Kz/Kr = 1.
Ss = 1.661E-8 ft^{-1}



6 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\PI-3\Slug_PI_3C_6a(-1)confined.aqt
Date: 02/13/14 Time: 17:18:44

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: PI-3C
Test Date: 07/31/2013

AQUIFER DATA

Saturated Thickness: 10. ft

WELL DATA (PI-3C)

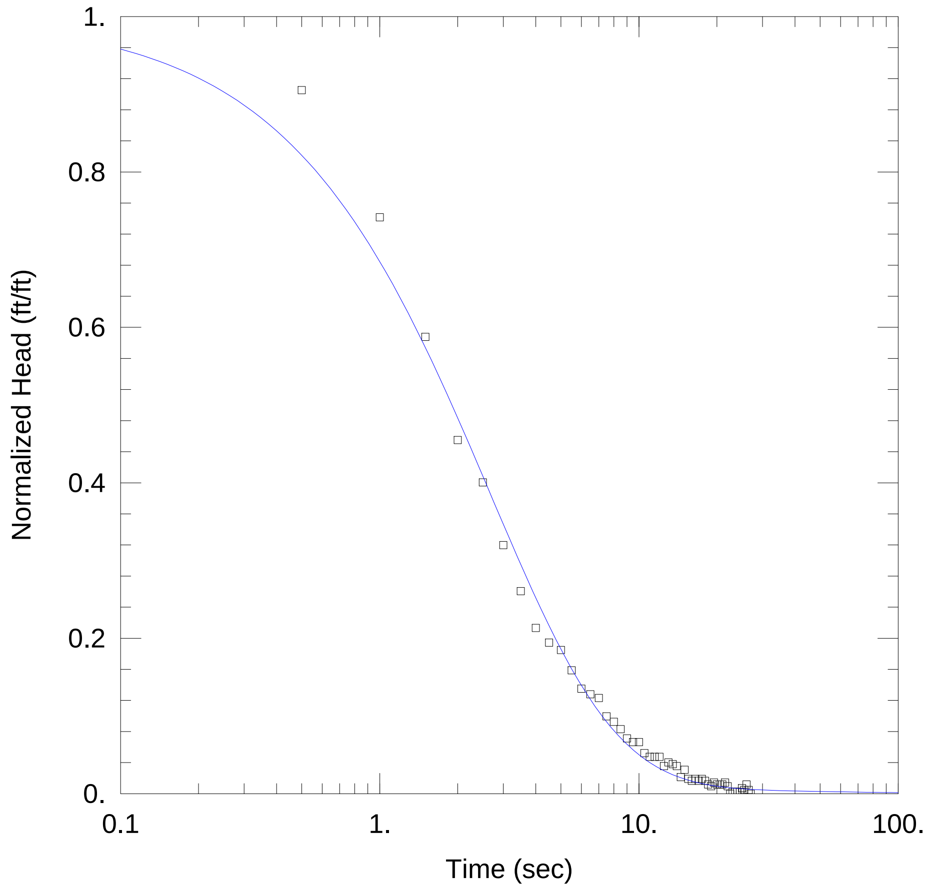
Initial Displacement: 0.409 ft
Total Well Penetration Depth: 10. ft
Casing Radius: 0.042 ft

Static Water Column Height: 0. ft
Screen Length: 10. ft
Well Radius: 0.042 ft
Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined
Solution Method: KGS Model

Kr = 0.01723 cm/sec
Kz/Kr = 1.
Ss = 4.125E-12 ft^{-1}



6 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\PI-3\Slug_PI_3C_6b(-1)confined.aqt
Date: 02/13/14 Time: 17:20:42

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: PI-3C
Test Date: 07/31/2013

AQUIFER DATA

Saturated Thickness: 10. ft

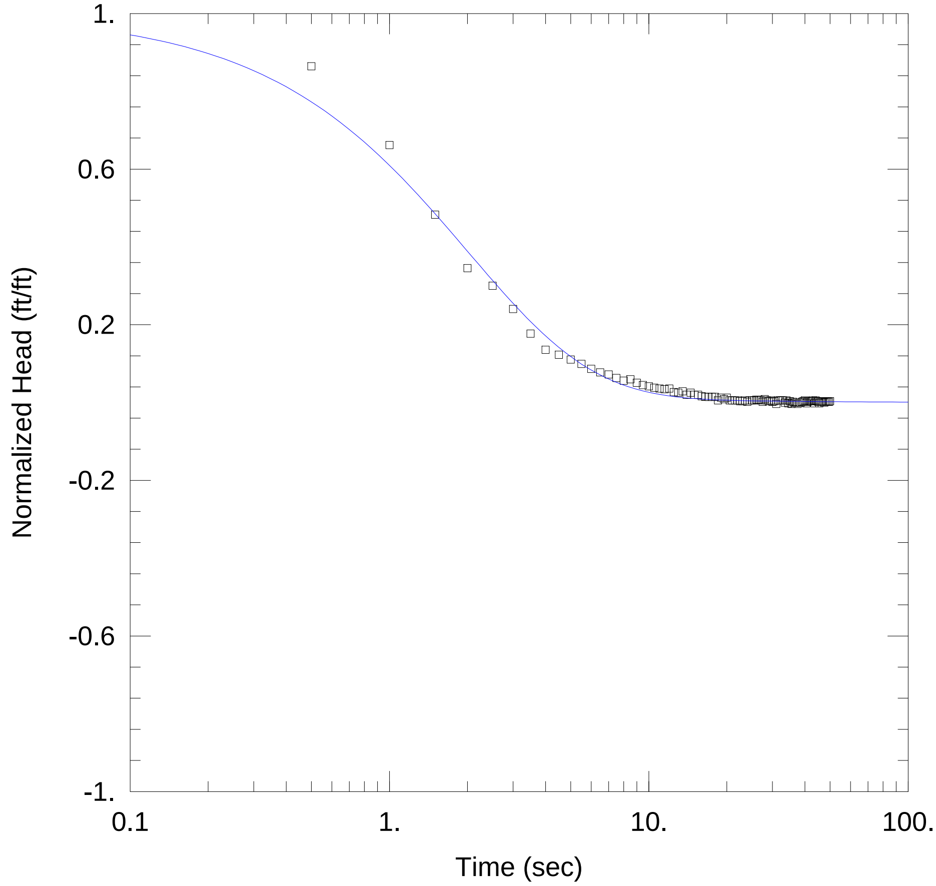
WELL DATA (PI-3C)

Initial Displacement: 0.3517 ft
Total Well Penetration Depth: 10. ft
Casing Radius: 0.042 ft
Static Water Column Height: 0. ft
Screen Length: 10. ft
Well Radius: 0.042 ft
Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined
Solution Method: KGS Model

Kr = 0.01551 cm/sec
Kz/Kr = 1.
Ss = 1.488E-10 ft^{-1}



9 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\PI-3\Slug_PI_3C_9a(-1)confined.aqt
Date: 02/13/14 Time: 17:22:42

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: PI-3C
Test Date: 07/31/2013

AQUIFER DATA

Saturated Thickness: 10. ft

WELL DATA (PI-3C)

Initial Displacement: 0.553 ft
Total Well Penetration Depth: 10. ft
Casing Radius: 0.042 ft

Static Water Column Height: 0. ft
Screen Length: 10. ft
Well Radius: 0.042 ft
Gravel Pack Porosity: 0.

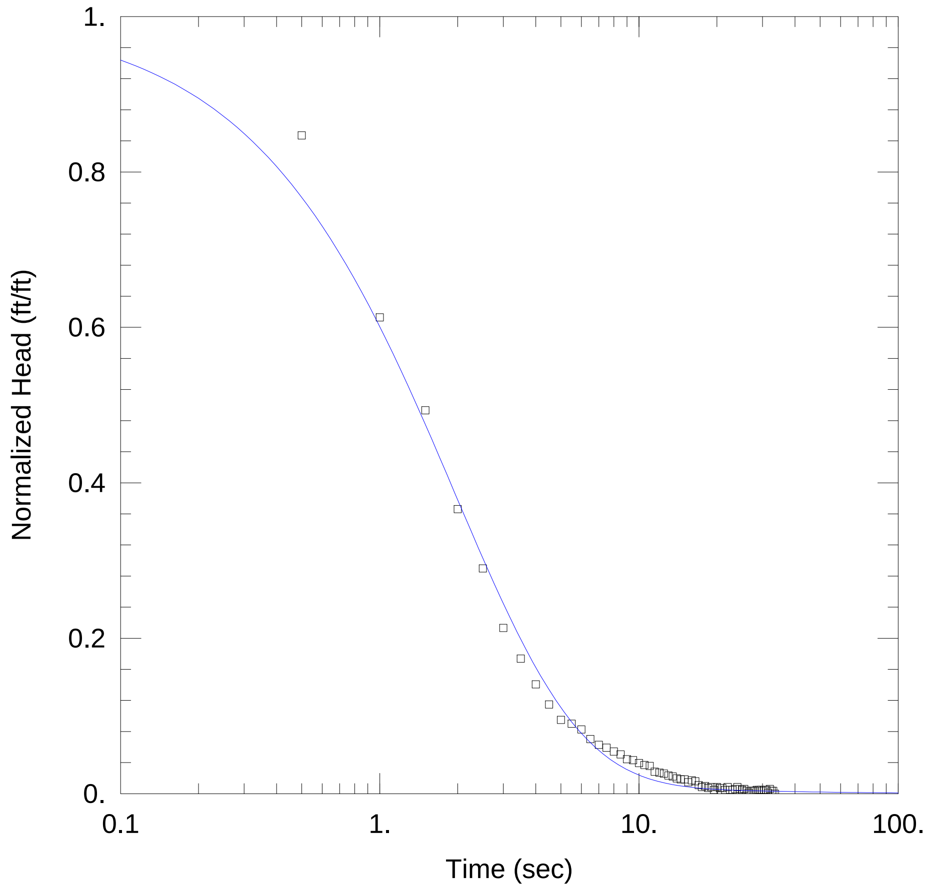
SOLUTION

Aquifer Model: Confined

Solution Method: KGS Model

Kr = 0.01865 cm/sec
Kz/Kr = 1.

Ss = 4.062E-10 ft^{-1}



9 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\PI-3\Slug_PI_3C_9b(-1)confined.aqt
Date: 02/13/14 Time: 17:24:01

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: PI-3C
Test Date: 07/31/2013

AQUIFER DATA

Saturated Thickness: 10. ft

WELL DATA (PI-3C)

Initial Displacement: 0.6758 ft
Total Well Penetration Depth: 10. ft
Casing Radius: 0.042 ft

Static Water Column Height: 0. ft
Screen Length: 10. ft
Well Radius: 0.042 ft
Gravel Pack Porosity: 0.

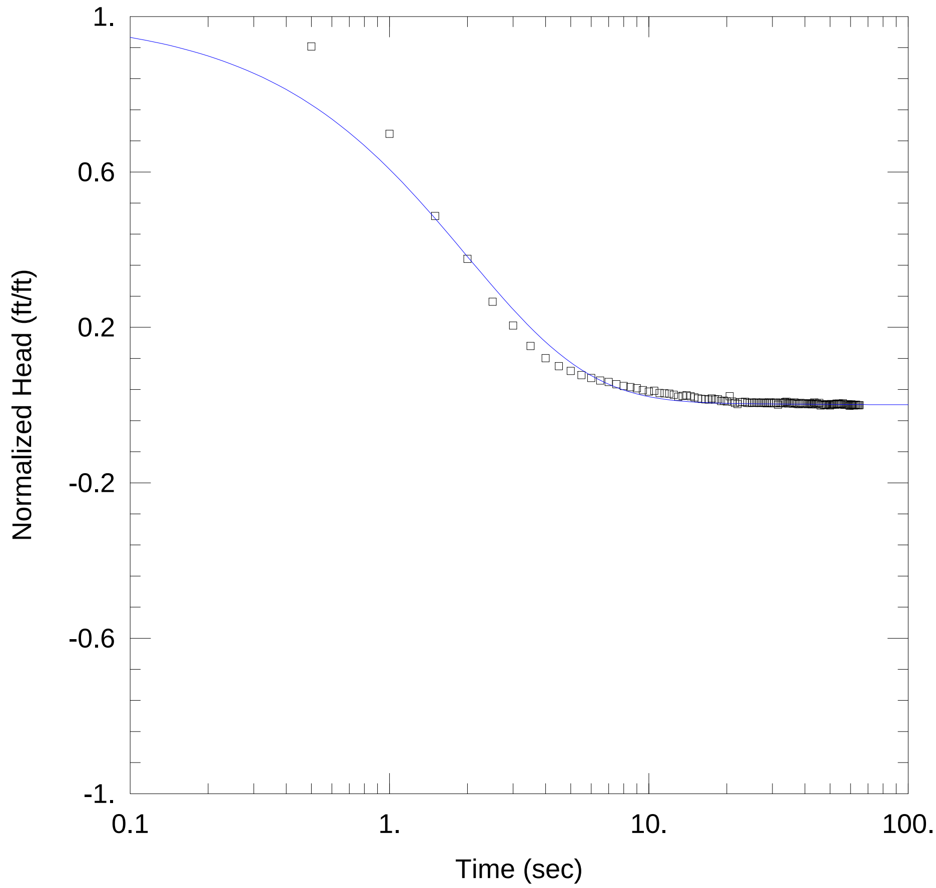
SOLUTION

Aquifer Model: Confined

Solution Method: KGS Model

Kr = 0.01626 cm/sec
Kz/Kr = 1.

Ss = 1.719E-10 ft^{-1}



12 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\PI-3\Slug_PI_3C_12a(-1)confined.aqt
Date: 02/13/14 Time: 17:26:38

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: PI-3C
Test Date: 07/31/2013

AQUIFER DATA

Saturated Thickness: 10. ft

WELL DATA (PI-3C)

Initial Displacement: 0.8833 ft
Total Well Penetration Depth: 10. ft
Casing Radius: 0.042 ft

Static Water Column Height: 0. ft
Screen Length: 10. ft
Well Radius: 0.042 ft
Gravel Pack Porosity: 0.

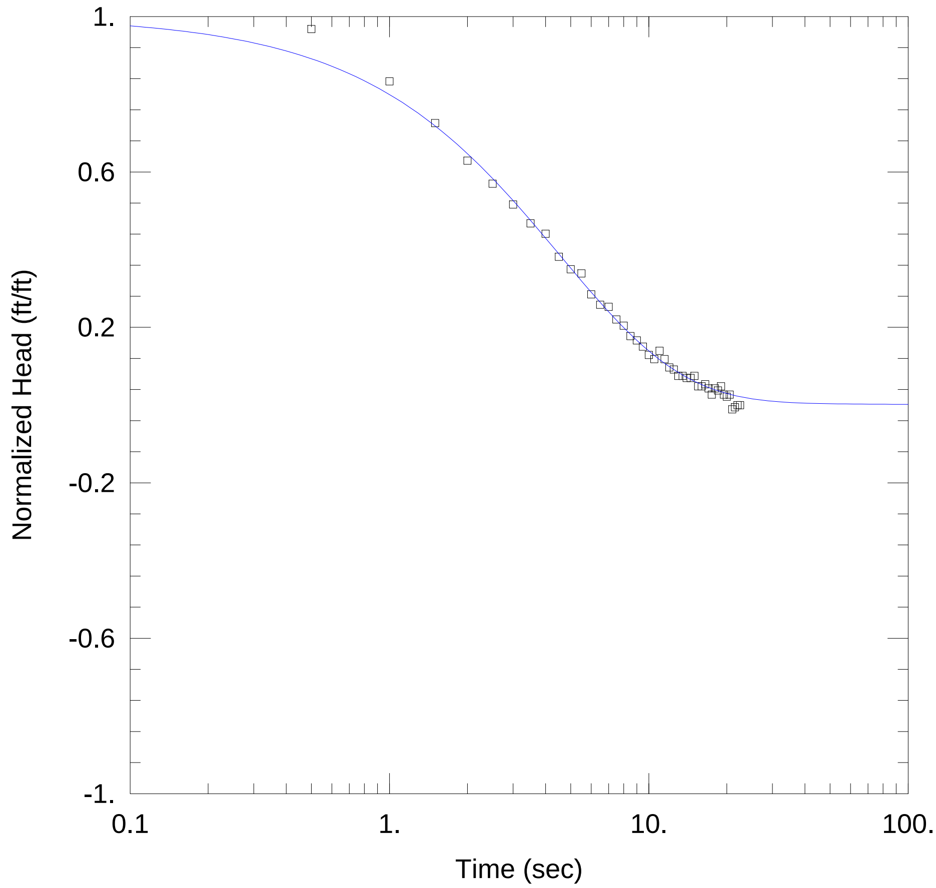
SOLUTION

Aquifer Model: Confined

Solution Method: KGS Model

Kr = 0.01992 cm/sec
Kz/Kr = 1.

Ss = 1.667E-12 ft^{-1}



3 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\PI-5\Slug_PI-5B_3a(-1)confined.aqt
Date: 02/13/14 Time: 13:03:13

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: PI-5B
Test Date: 07/31/2013

AQUIFER DATA

Saturated Thickness: 16. ft

WELL DATA (PI-5B)

Initial Displacement: 0.186 ft
Total Well Penetration Depth: 12.75 ft
Casing Radius: 0.042 ft

Static Water Column Height: 0. ft
Screen Length: 10. ft
Well Radius: 0.042 ft
Gravel Pack Porosity: 0.

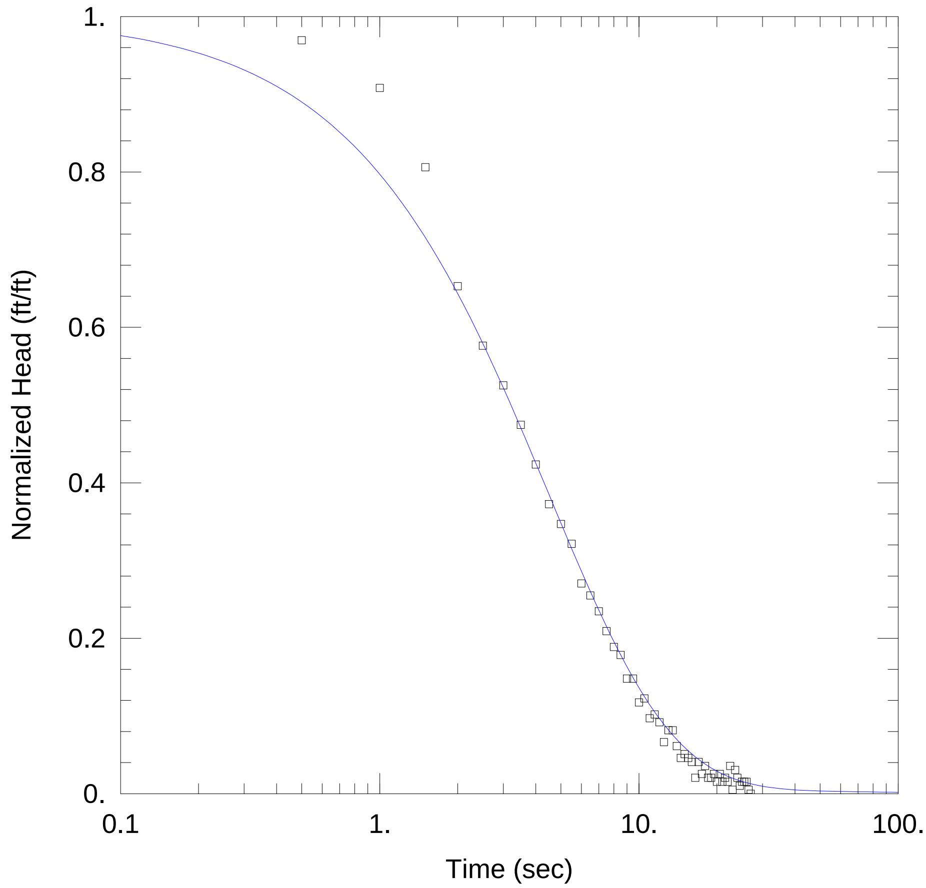
SOLUTION

Aquifer Model: Confined

Solution Method: KGS Model

Kr = 0.007164 cm/sec
Kz/Kr = 1.

Ss = 6.429E-12 ft^{-1}



3 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\PI-5\Slug_PI-5B_3b(-1)confined.aqt
Date: 02/13/14 Time: 13:05:52

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: PI-5B
Test Date: 07/31/2013

AQUIFER DATA

Saturated Thickness: 16. ft

WELL DATA (PI-5B)

Initial Displacement: 0.196 ft
Total Well Penetration Depth: 12.75 ft
Casing Radius: 0.042 ft

Static Water Column Height: 0. ft
Screen Length: 10. ft
Well Radius: 0.042 ft
Gravel Pack Porosity: 0.

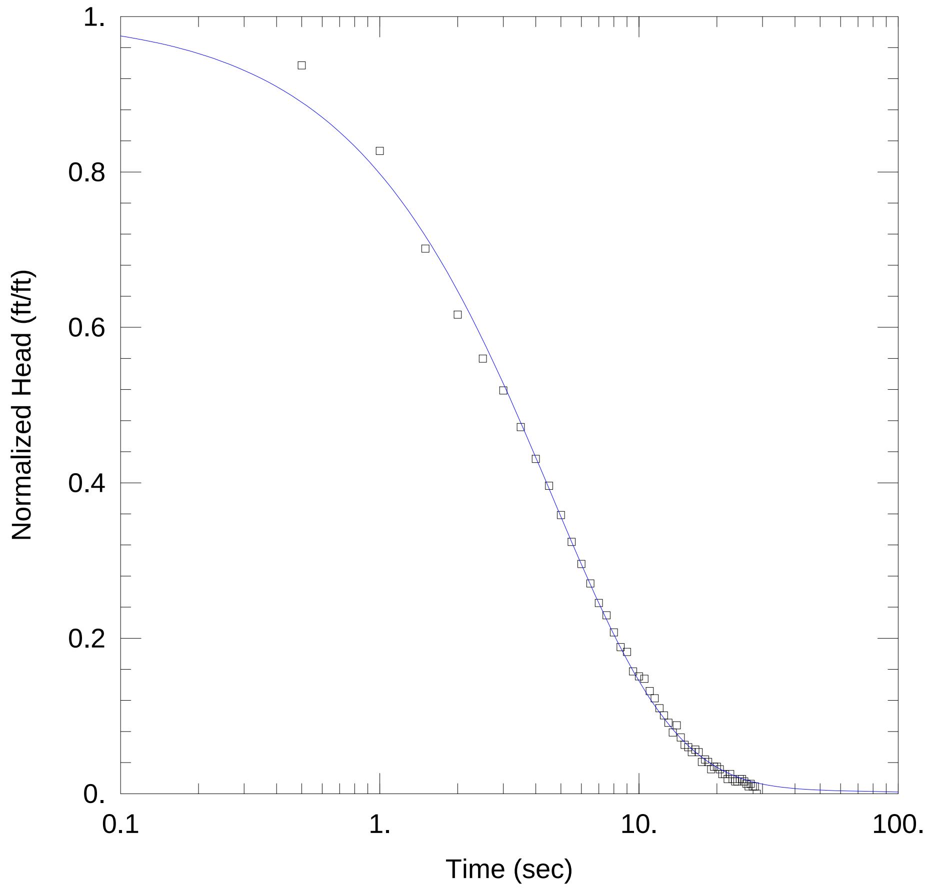
SOLUTION

Aquifer Model: Confined

Solution Method: KGS Model

Kr = 0.006872 cm/sec
Kz/Kr = 1.

Ss = 6.429E-12 ft^{-1}



6 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\PI-5\Slug_PI-5B_6a(-1)confined.aqt
Date: 02/13/14 Time: 13:12:40

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: PI-5B
Test Date: 07/31/2013

AQUIFER DATA

Saturated Thickness: 16. ft

WELL DATA (PI-5B)

Initial Displacement: 0.318 ft
Total Well Penetration Depth: 12.75 ft
Casing Radius: 0.042 ft

Static Water Column Height: 0. ft
Screen Length: 10. ft
Well Radius: 0.042 ft
Gravel Pack Porosity: 0.

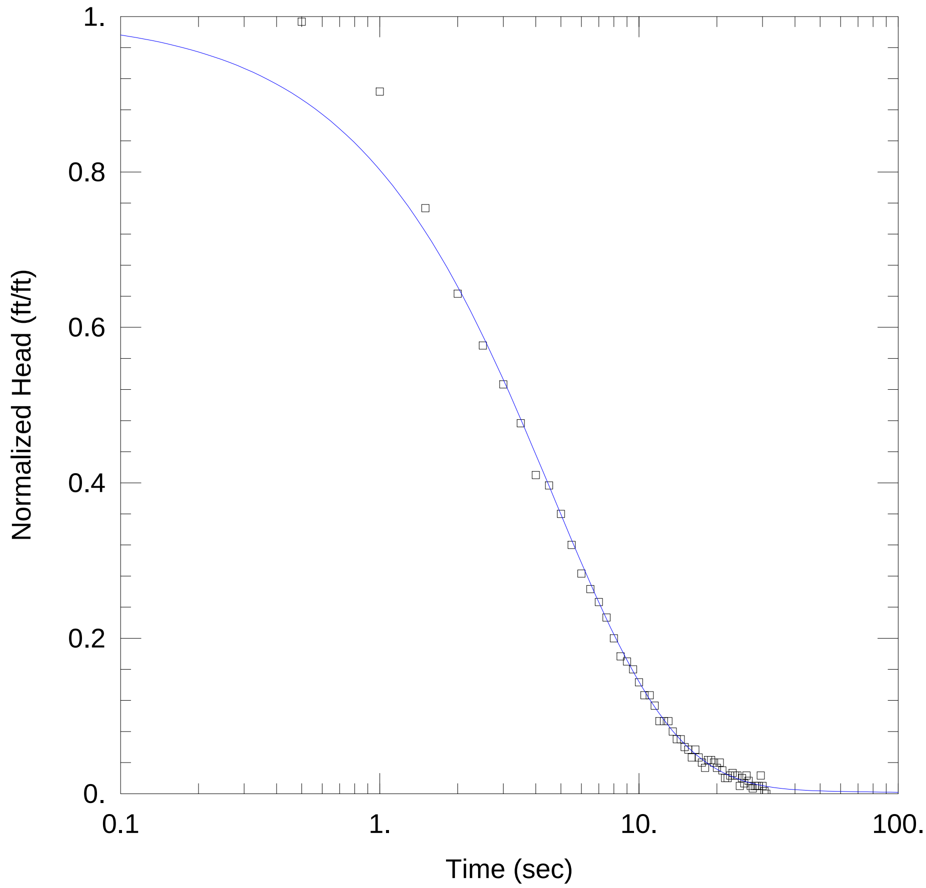
SOLUTION

Aquifer Model: Confined

Solution Method: KGS Model

Kr = 0.006687 cm/sec
Kz/Kr = 1.

Ss = 2.213E-9 ft^{-1}



6 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\PI-5\Slug_PI-5B_6b(-1)confined.aqt
Date: 02/13/14 Time: 13:14:36

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: PI-5B
Test Date: 07/31/2013

AQUIFER DATA

Saturated Thickness: 16. ft

WELL DATA (PI-5B)

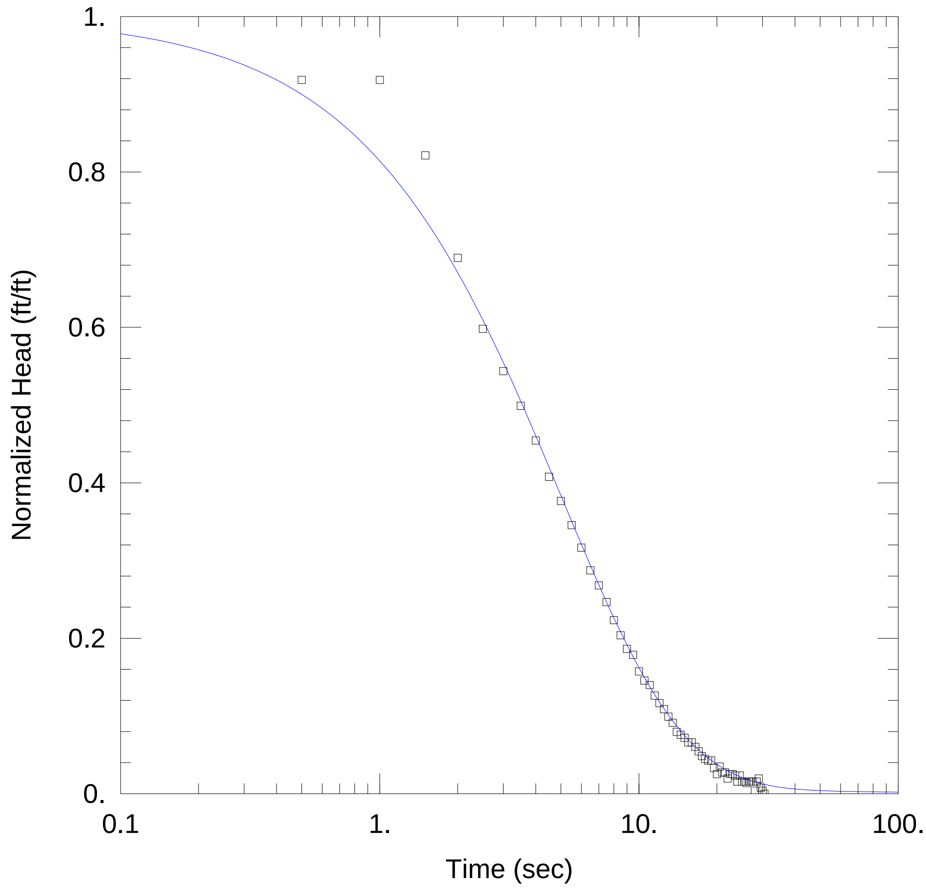
Initial Displacement: 0.3 ft
Total Well Penetration Depth: 12.75 ft
Casing Radius: 0.042 ft

Static Water Column Height: 0. ft
Screen Length: 10. ft
Well Radius: 0.042 ft
Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined
Solution Method: KGS Model

Kr = 0.008775 cm/sec
Kz/Kr = 1.
Ss = 6.429E-12 ft^{-1}



9 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\PI-5\Slug_PI-5B_9a(-1)confined.aqt
Date: 02/13/14 Time: 13:16:54

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: PI-5B
Test Date: 07/31/2013

AQUIFER DATA

Saturated Thickness: 16. ft

WELL DATA (PI-5B)

Initial Displacement: 0.515 ft
Total Well Penetration Depth: 12.75 ft
Casing Radius: 0.042 ft

Static Water Column Height: 0. ft
Screen Length: 10. ft
Well Radius: 0.042 ft
Gravel Pack Porosity: 0.

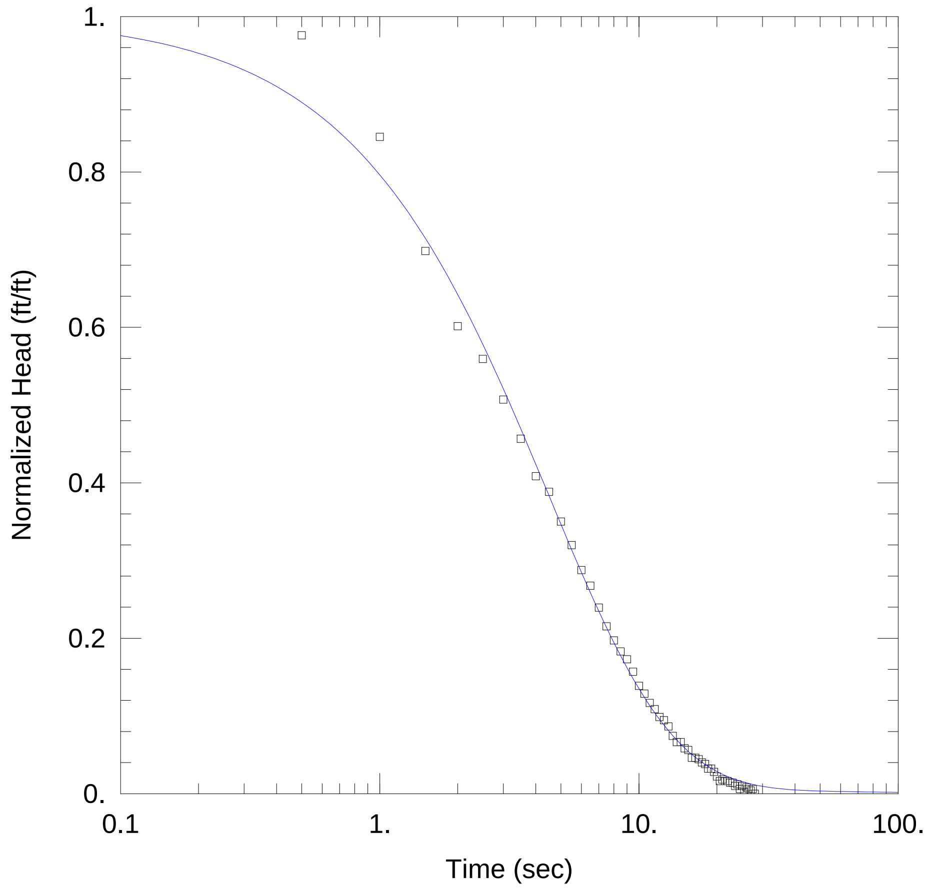
SOLUTION

Aquifer Model: Confined

Solution Method: KGS Model

Kr = 0.007116 cm/sec
Kz/Kr = 1.

Ss = 6.429E-12 ft^{-1}



9 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\PI-5\Slug_PI-5B_9b(-1)confined.aqt
Date: 02/13/14 Time: 13:20:13

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: PI-5B
Test Date: 07/31/2013

AQUIFER DATA

Saturated Thickness: 16. ft

WELL DATA (PI-5B)

Initial Displacement: 0.497 ft
Total Well Penetration Depth: 12.75 ft
Casing Radius: 0.042 ft

Static Water Column Height: 0. ft
Screen Length: 10. ft
Well Radius: 0.042 ft
Gravel Pack Porosity: 0.

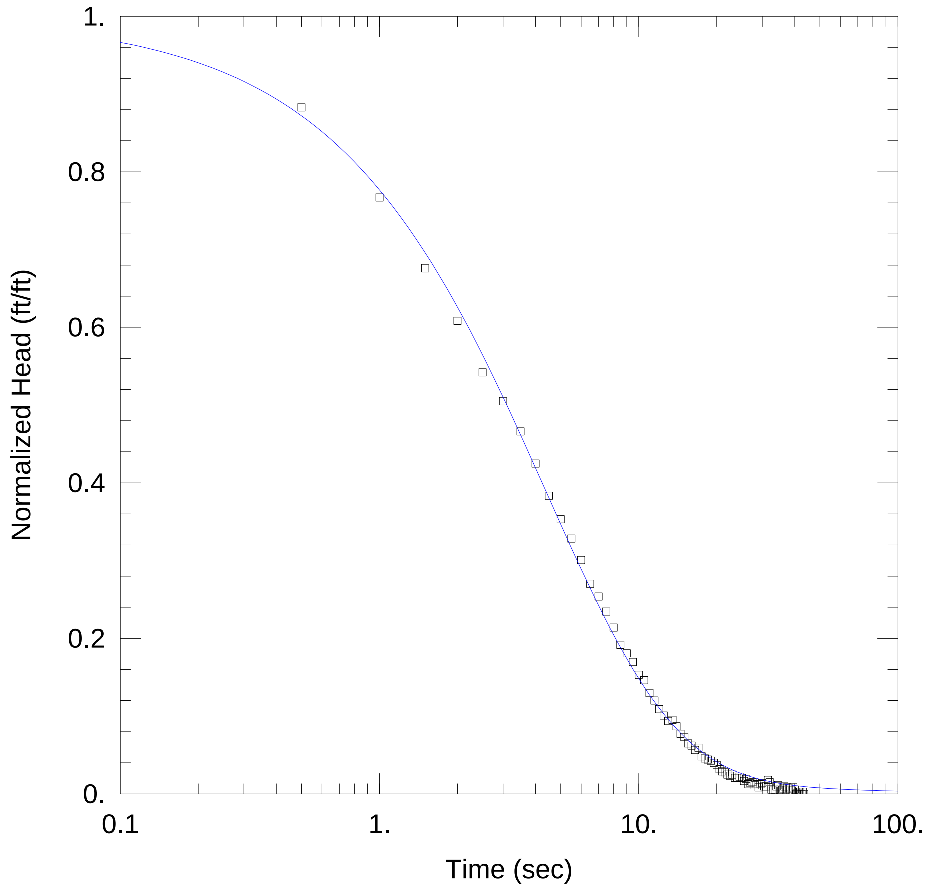
SOLUTION

Aquifer Model: Confined

Solution Method: KGS Model

Kr = 0.008213 cm/sec
Kz/Kr = 1.

Ss = 6.429E-12 ft^{-1}



12 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\PI-5\Slug_PI-5B_12a(-1)confined.aqt
Date: 02/13/14 Time: 13:22:12

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: PI-5B
Test Date: 07/31/2013

AQUIFER DATA

Saturated Thickness: 16. ft

WELL DATA (PI-5B)

Initial Displacement: 0.725 ft
Total Well Penetration Depth: 12.75 ft
Casing Radius: 0.042 ft

Static Water Column Height: 0. ft
Screen Length: 10. ft
Well Radius: 0.042 ft
Gravel Pack Porosity: 0.

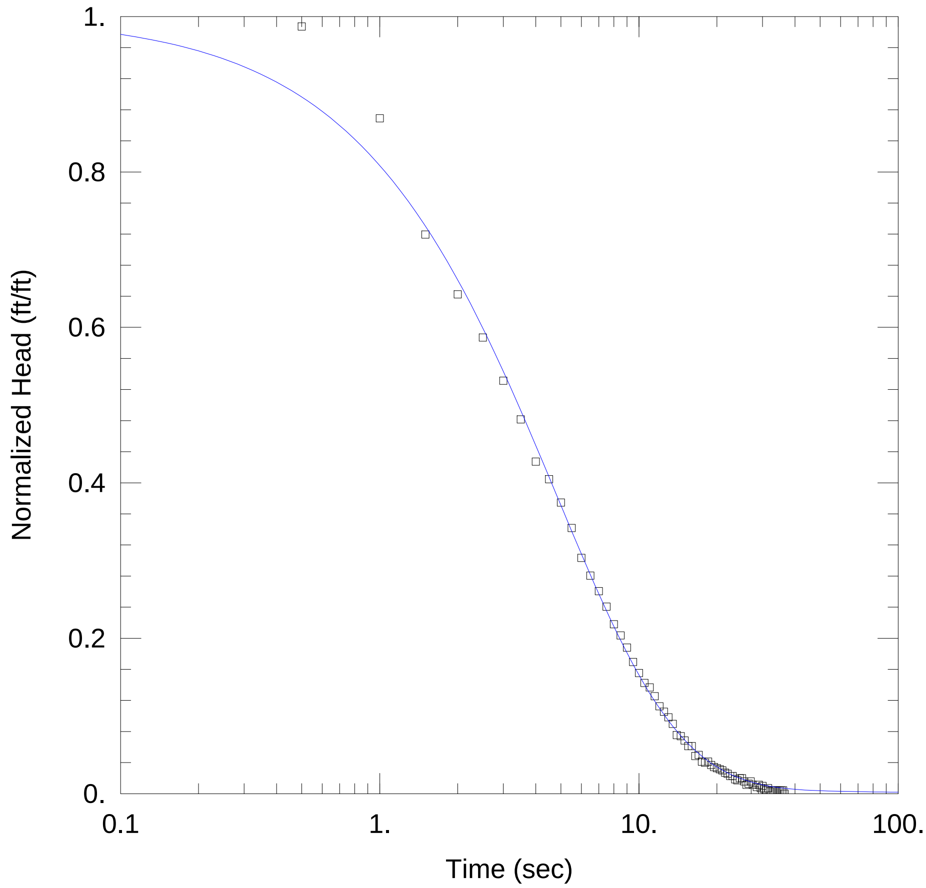
SOLUTION

Aquifer Model: Confined

Solution Method: KGS Model

Kr = 0.003704 cm/sec
Kz/Kr = 1.

Ss = 1.69E-5 ft^{-1}



12 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\PI-5\Slug_PI-5B_12b(-1)confined.aqt
Date: 02/13/14 Time: 13:24:39

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: PI-5B
Test Date: 07/31/2013

AQUIFER DATA

Saturated Thickness: 16. ft

WELL DATA (PI-5B)

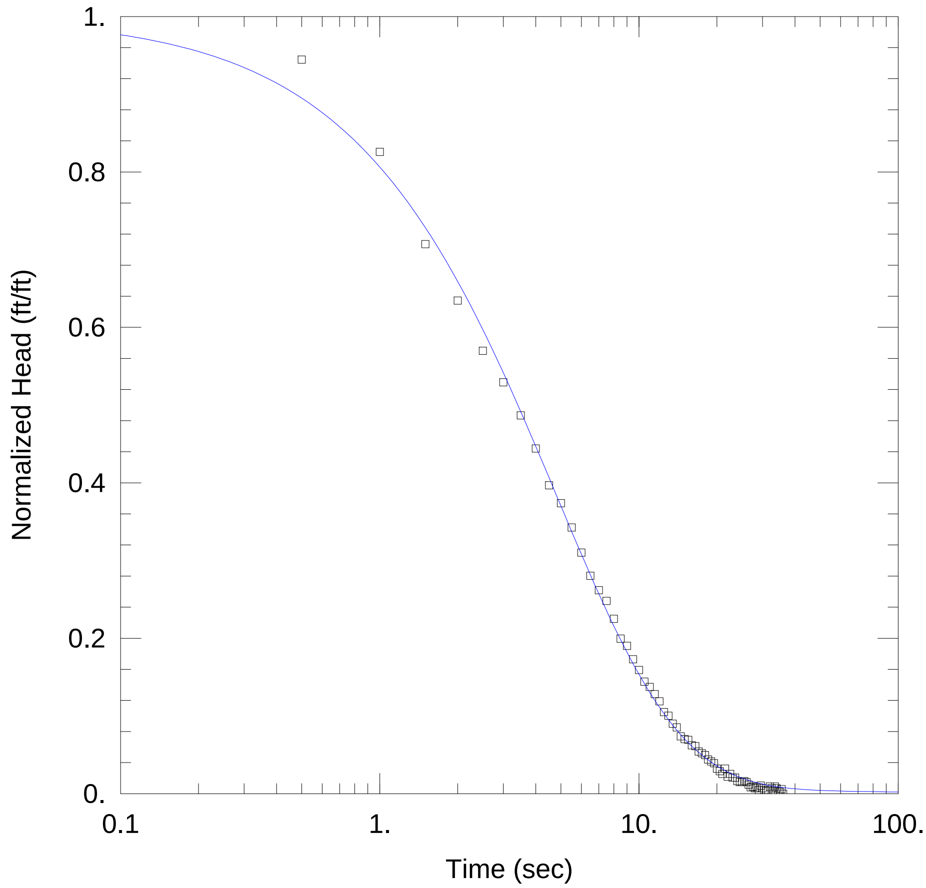
Initial Displacement: 0.702 ft
Total Well Penetration Depth: 12.75 ft
Casing Radius: 0.042 ft

Static Water Column Height: 0. ft
Screen Length: 10. ft
Well Radius: 0.042 ft
Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined
Solution Method: KGS Model

Kr = 0.007213 cm/sec
Kz/Kr = 1.
Ss = 6.429E-12 ft^{-1}



15 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\PI-5\Slug_PI-5B_15a(-1)confined.aqt
Date: 02/13/14 Time: 13:27:16

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: PI-5B
Test Date: 07/31/2013

AQUIFER DATA

Saturated Thickness: 16. ft

WELL DATA (PI-5B)

Initial Displacement: 0.867 ft
Total Well Penetration Depth: 12.75 ft
Casing Radius: 0.042 ft

Static Water Column Height: 0. ft
Screen Length: 10. ft
Well Radius: 0.042 ft
Gravel Pack Porosity: 0.

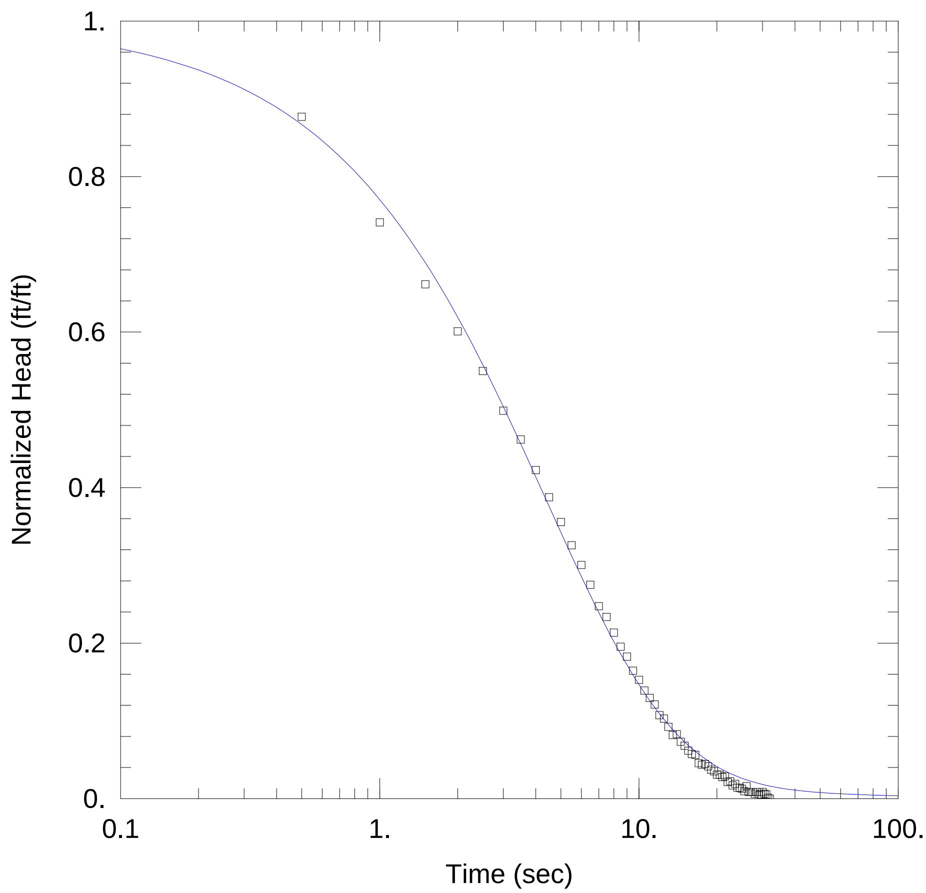
SOLUTION

Aquifer Model: Confined

Solution Method: KGS Model

Kr = 0.006563 cm/sec
Kz/Kr = 1.

Ss = 1.351E-10 ft^{-1}



15 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\PI-5\Slug_PI-5B_15b(-1)confined.aqt
Date: 02/13/14 Time: 13:29:10

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: PI-5B
Test Date: 07/31/2013

AQUIFER DATA

Saturated Thickness: 16. ft

WELL DATA (PI-5B)

Initial Displacement: 0.942 ft
Total Well Penetration Depth: 12.75 ft
Casing Radius: 0.042 ft

Static Water Column Height: 0. ft
Screen Length: 10. ft
Well Radius: 0.042 ft
Gravel Pack Porosity: 0.

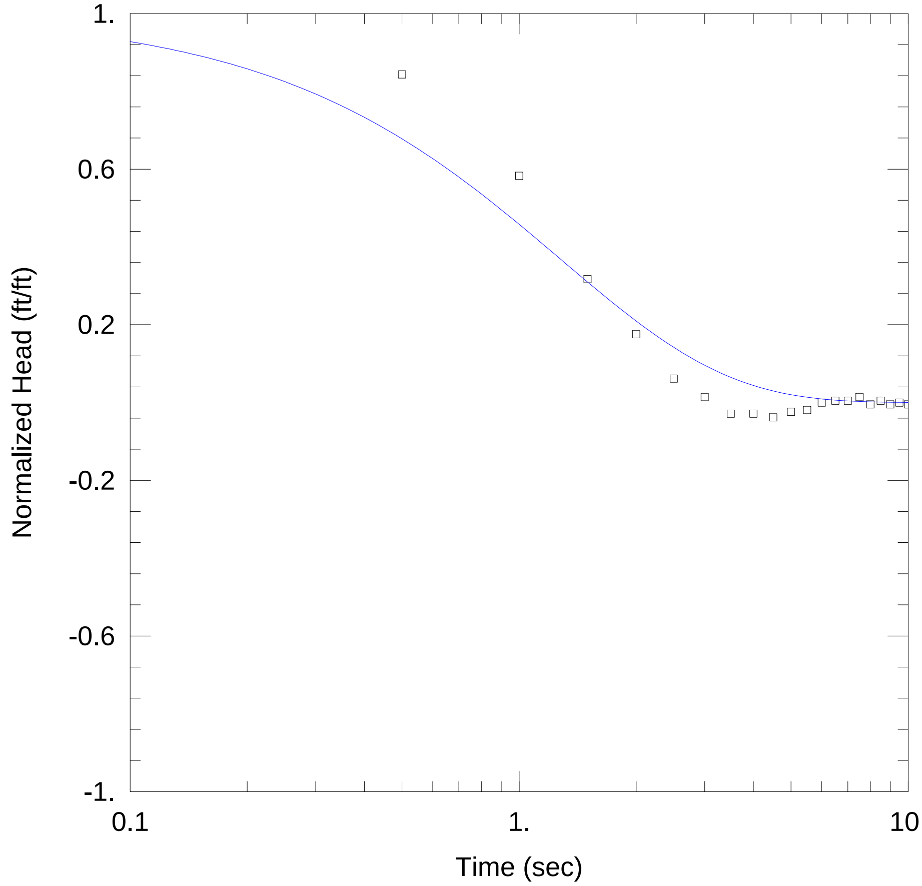
SOLUTION

Aquifer Model: Confined

Solution Method: KGS Model

Kr = 0.003477 cm/sec
Kz/Kr = 1.

Ss = 2.782E-5 ft^{-1}



5 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\PI-6\Slug_PI-6B_5a(-1)confined.aqt
Date: 02/13/14 Time: 13:35:32

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: PI-6B
Test Date: 07/31/2013

AQUIFER DATA

Saturated Thickness: 45. ft Anisotropy Ratio (Kz/Kr): 1.

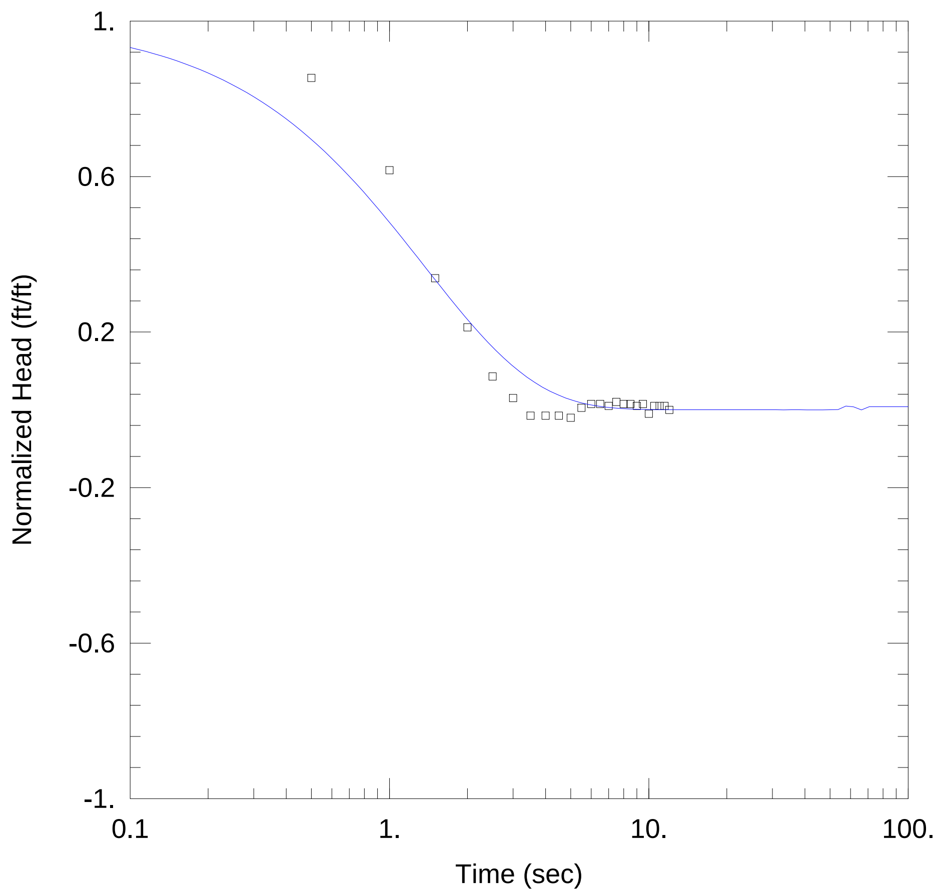
WELL DATA (PI-6B)

Initial Displacement: 0.211 ft
Total Well Penetration Depth: 18.83 ft
Casing Radius: 0.042 ft
Static Water Column Height: 0. ft
Screen Length: 10. ft
Well Radius: 0.042 ft

SOLUTION

Aquifer Model: Confined
Solution Method: McElwee-Zenner

K = 0.0115 cm/sec
A = 6.968E-310
ß = 1.698E-313 ft
v(0) = 1.976E-323 cm/sec



5 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\PI-6\Slug_PI-6B_5b(-1)confined.aqt
Date: 02/13/14 Time: 13:37:07

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: PI-6B
Test Date: 07/31/2013

AQUIFER DATA

Saturated Thickness: 45. ft Anisotropy Ratio (Kz/Kr): 1.

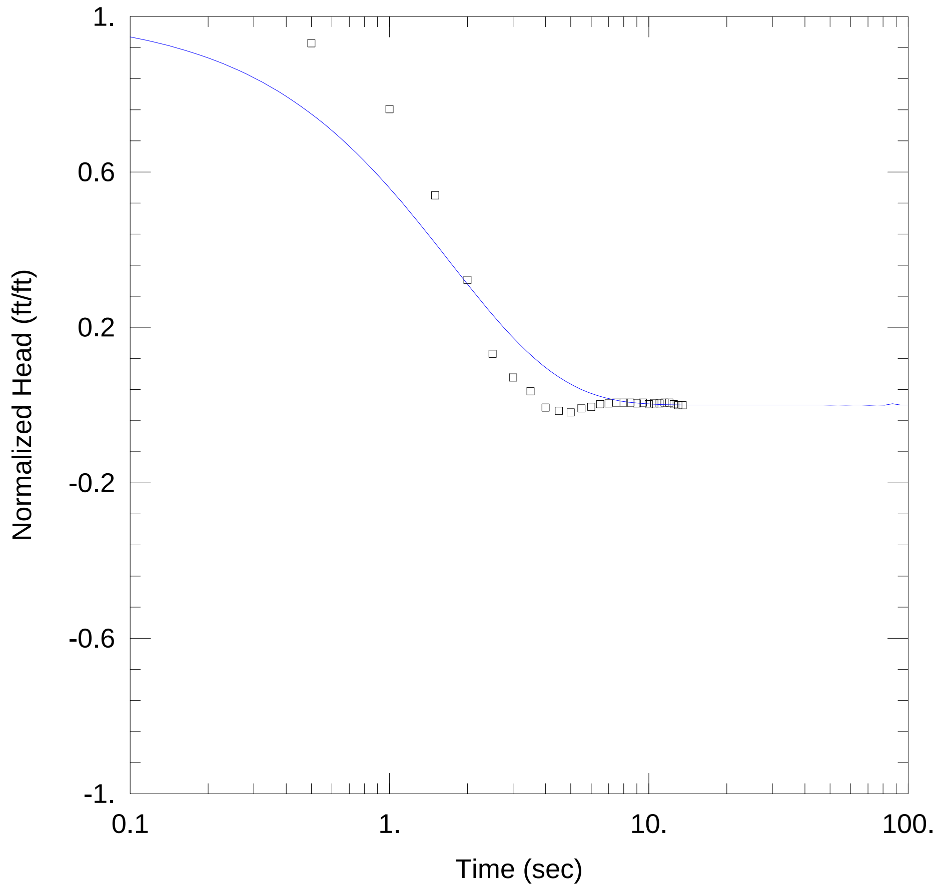
WELL DATA (PI-6B)

Initial Displacement: 0.198 ft
Total Well Penetration Depth: 18.83 ft
Casing Radius: 0.042 ft
Static Water Column Height: 0. ft
Screen Length: 10. ft
Well Radius: 0.042 ft

SOLUTION

Aquifer Model: Confined
Solution Method: McElwee-Zenner

K = 0.01074 cm/sec
A = 6.968E-310
ß = 1.698E-313 ft
v(0) = 1.976E-323 cm/sec



10 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\PI-6\Slug_PI-6B_10a(-1)confined.aqt
Date: 02/13/14 Time: 13:39:21

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: PI-6B
Test Date: 07/31/2013

AQUIFER DATA

Saturated Thickness: 45. ft Anisotropy Ratio (Kz/Kr): 1.

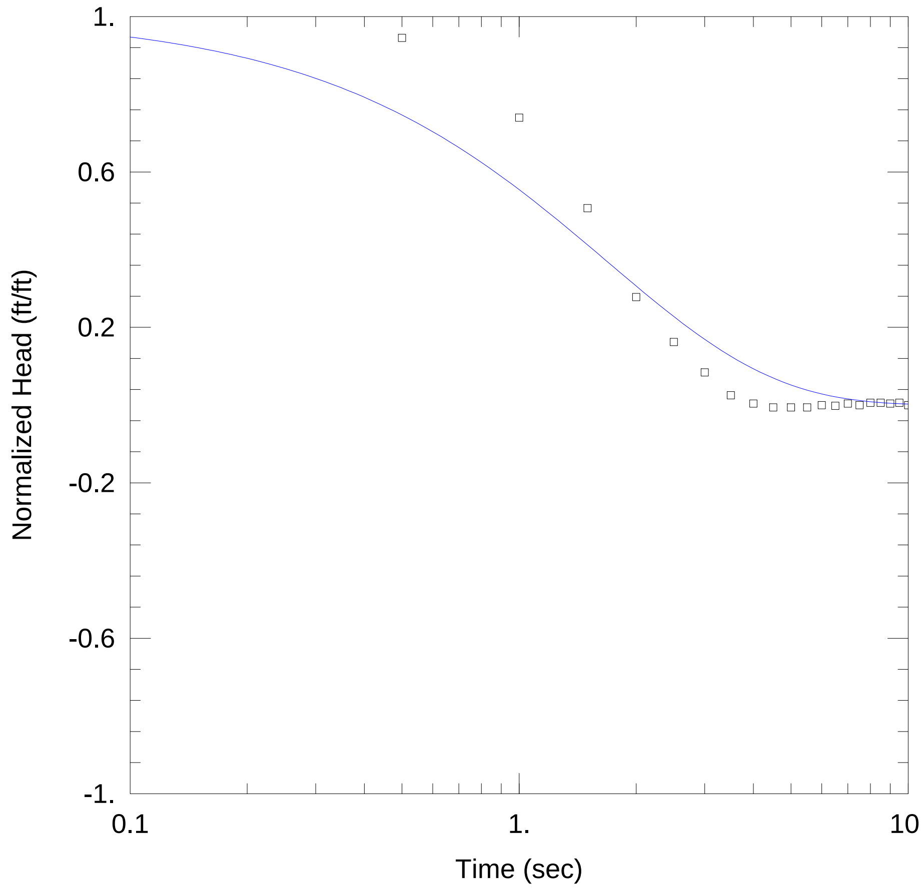
WELL DATA (PI-6B)

Initial Displacement: 0.478 ft
Total Well Penetration Depth: 18.83 ft
Casing Radius: 0.042 ft
Static Water Column Height: 0. ft
Screen Length: 10. ft
Well Radius: 0.042 ft

SOLUTION

Aquifer Model: Confined Solution Method: McElwee-Zenner

K = 0.0086 cm/sec
A = 6.968E-310
ß = 1.698E-313 ft
v(0) = 1.976E-323 cm/sec



10 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\PI-6\Slug_PI-6B_10b(-1)confined.aqt
Date: 02/13/14 Time: 13:43:43

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: PI-6B
Test Date: 07/31/2013

AQUIFER DATA

Saturated Thickness: 45. ft
Anisotropy Ratio (Kz/Kr): 1.

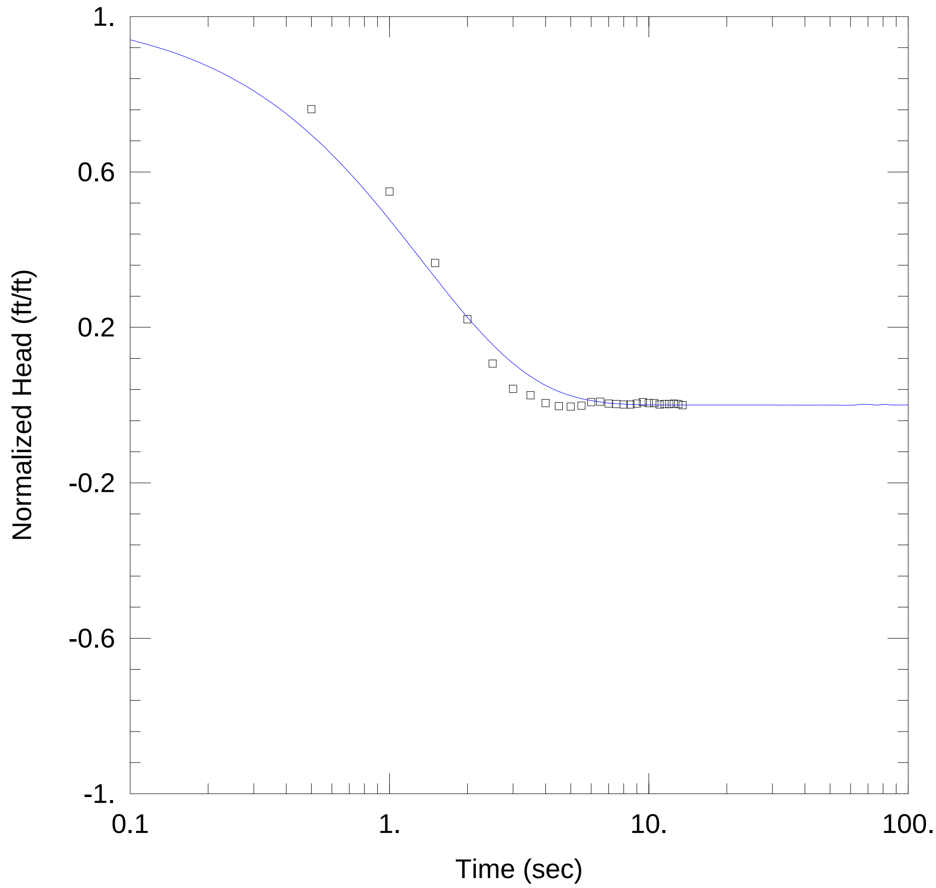
WELL DATA (PI-6B)

Initial Displacement: 0.511 ft
Static Water Column Height: 0. ft
Total Well Penetration Depth: 18.83 ft
Screen Length: 10. ft
Casing Radius: 0.042 ft
Well Radius: 0.042 ft

SOLUTION

Aquifer Model: Confined
Solution Method: McElwee-Zenner

K = 0.008716 cm/sec
ß = 1.698E-313 ft
A = 6.968E-310
v(0) = 1.976E-323 cm/sec



15 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\PI-6\Slug_PI-6B_15a(-1)confined.aqt
Date: 02/13/14 Time: 13:47:17

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: PI-6B
Test Date: 07/31/2013

AQUIFER DATA

Saturated Thickness: 45. ft
Anisotropy Ratio (Kz/Kr): 1.

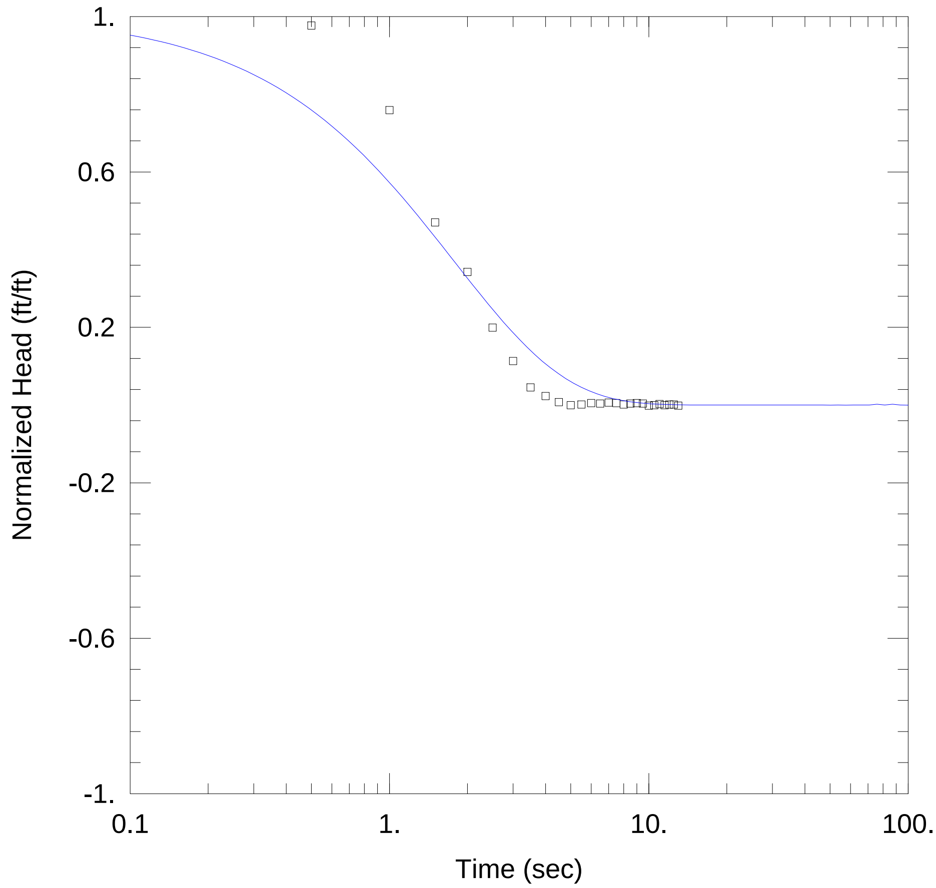
WELL DATA (PI-6B)

Initial Displacement: 0.788 ft
Static Water Column Height: 0. ft
Total Well Penetration Depth: 18.83 ft
Screen Length: 10. ft
Casing Radius: 0.042 ft
Well Radius: 0.042 ft

SOLUTION

Aquifer Model: Confined
Solution Method: McElwee-Zenner

K = 0.01097 cm/sec
ß = 1.698E-313 ft
A = 6.968E-310
v(0) = 1.976E-323 cm/sec



15 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\PI-6\Slug_PI-6B_15b(-1)confined.aqt
Date: 02/13/14 Time: 13:49:23

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: PI-6B
Test Date: 07/31/2013

AQUIFER DATA

Saturated Thickness: 45. ft
Anisotropy Ratio (Kz/Kr): 1.

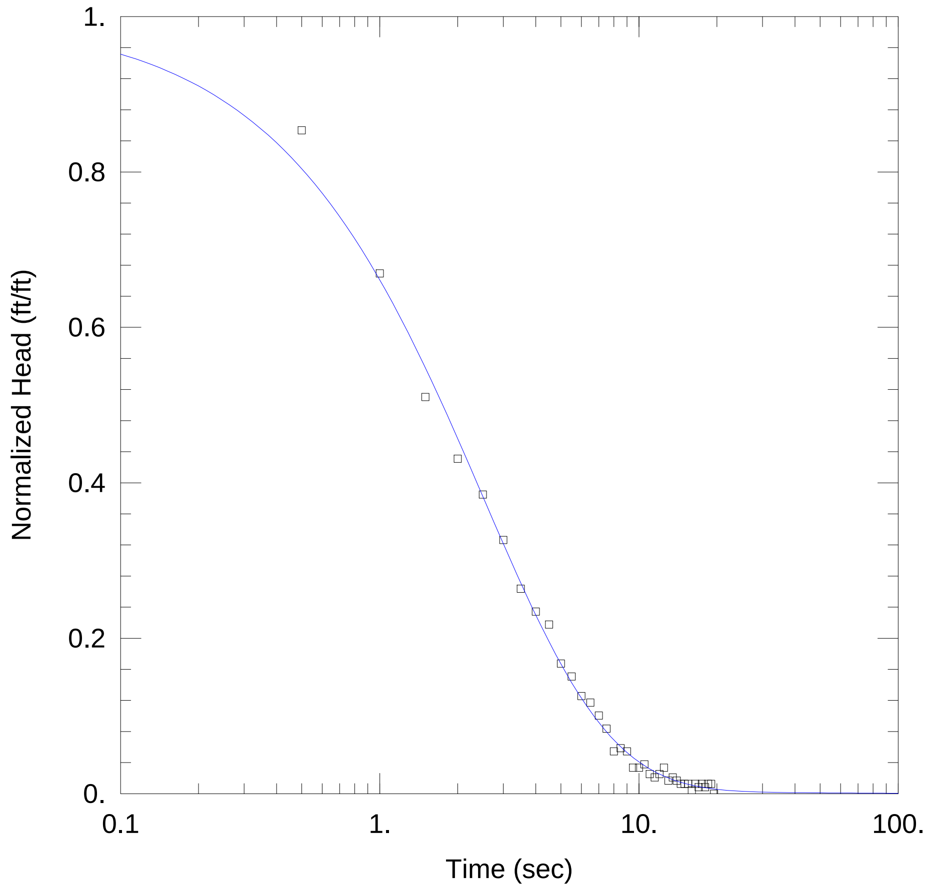
WELL DATA (PI-6B)

Initial Displacement: 0.768 ft
Total Well Penetration Depth: 18.83 ft
Casing Radius: 0.042 ft
Static Water Column Height: 0. ft
Screen Length: 10. ft
Well Radius: 0.042 ft

SOLUTION

Aquifer Model: Confined
Solution Method: McElwee-Zenner

K = 0.008257 cm/sec
A = 6.968E-310
ß = 1.698E-313 ft
v(0) = 1.976E-323 cm/sec



5 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\PI-7\Slug_PI-7B_5a(-1)confined.aqt
Date: 02/13/14 Time: 13:56:47

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: PI-7B
Test Date: 08/05/2013

AQUIFER DATA

Saturated Thickness: 39. ft

WELL DATA (PI-7B)

Initial Displacement: 0.239 ft
Total Well Penetration Depth: 20.92 ft
Casing Radius: 0.042 ft

Static Water Column Height: 0. ft
Screen Length: 10. ft
Well Radius: 0.042 ft
Gravel Pack Porosity: 0.

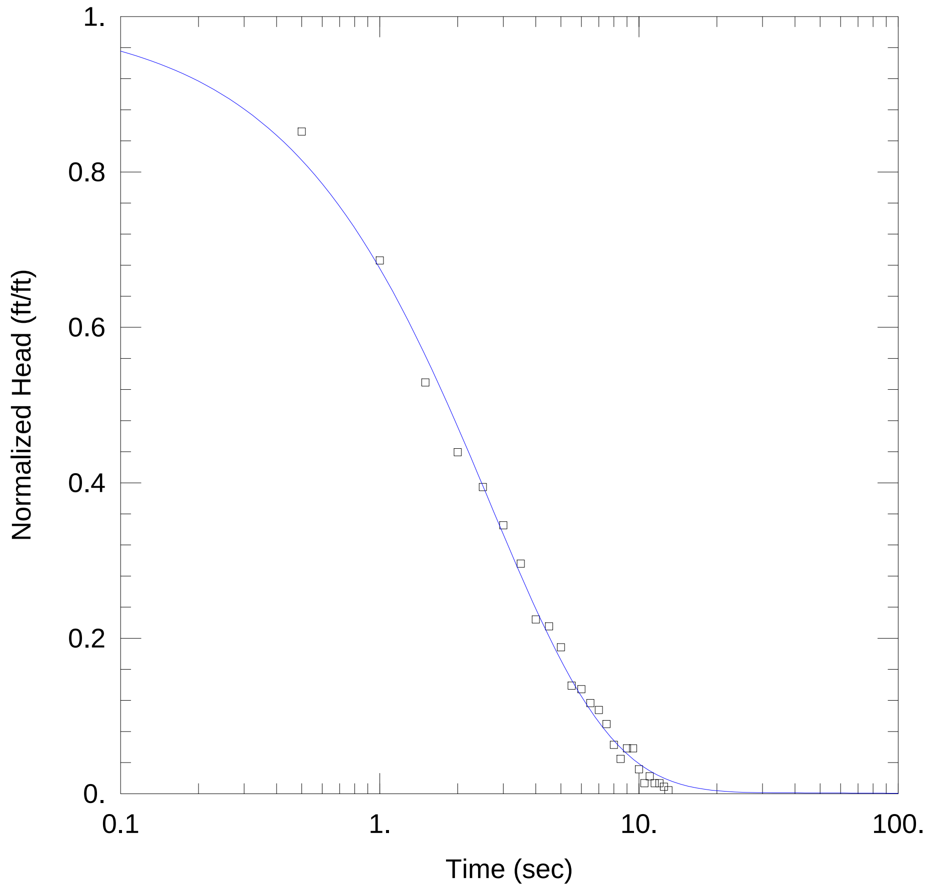
SOLUTION

Aquifer Model: Confined

Solution Method: KGS Model

Kr = 0.01359 cm/sec
Kz/Kr = 0.001

Ss = 1.661E-7 ft^{-1}



5 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\PI-7\Slug_PI-7B_5b(-1)confined.aqt
Date: 02/13/14 Time: 14:01:26

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: PI-7B
Test Date: 08/05/2013

AQUIFER DATA

Saturated Thickness: 39. ft

WELL DATA (PI-7B)

Initial Displacement: 0.223 ft
Total Well Penetration Depth: 20.92 ft
Casing Radius: 0.042 ft

Static Water Column Height: 0. ft
Screen Length: 10. ft
Well Radius: 0.042 ft
Gravel Pack Porosity: 0.

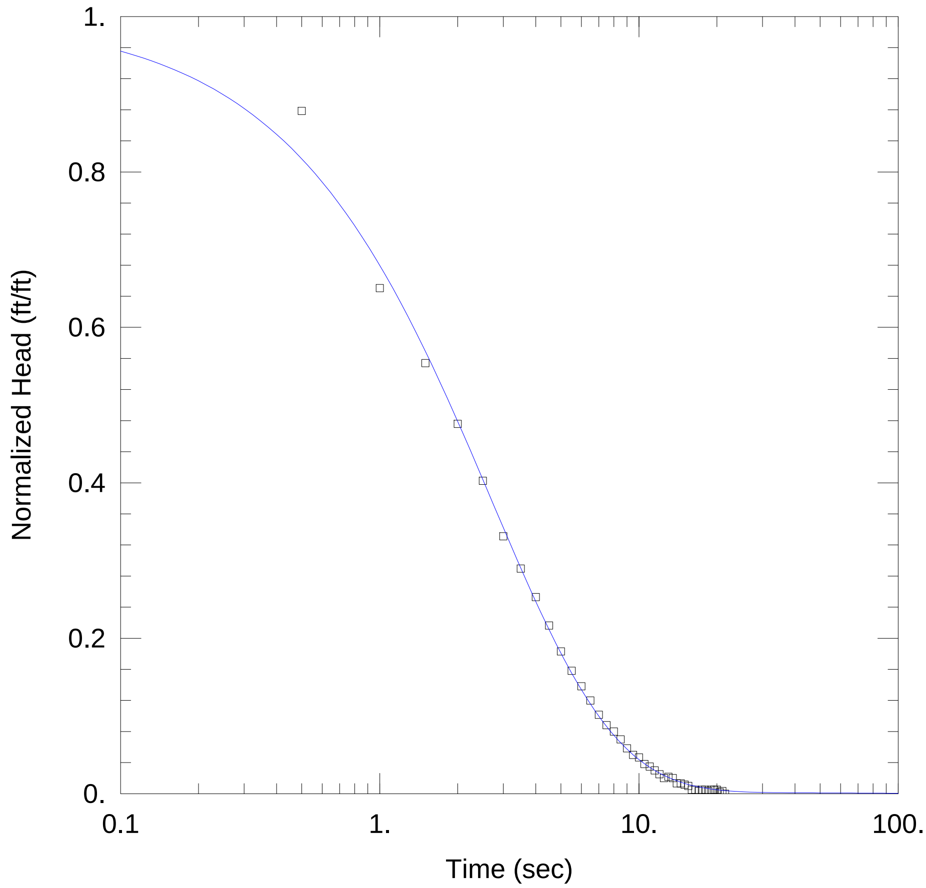
SOLUTION

Aquifer Model: Confined

Solution Method: KGS Model

Kr = 0.01479 cm/sec
Kz/Kr = 0.001

Ss = 5.033E-8 ft^{-1}



10 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\PI-7\Slug_PI-7B_10a(-1)confined.aqt
Date: 02/13/14 Time: 14:03:30

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: PI-7B
Test Date: 08/05/2013

AQUIFER DATA

Saturated Thickness: 39. ft

WELL DATA (PI-7B)

Initial Displacement: 0.601 ft
Total Well Penetration Depth: 20.92 ft
Casing Radius: 0.042 ft

Static Water Column Height: 0. ft
Screen Length: 10. ft
Well Radius: 0.042 ft
Gravel Pack Porosity: 0.

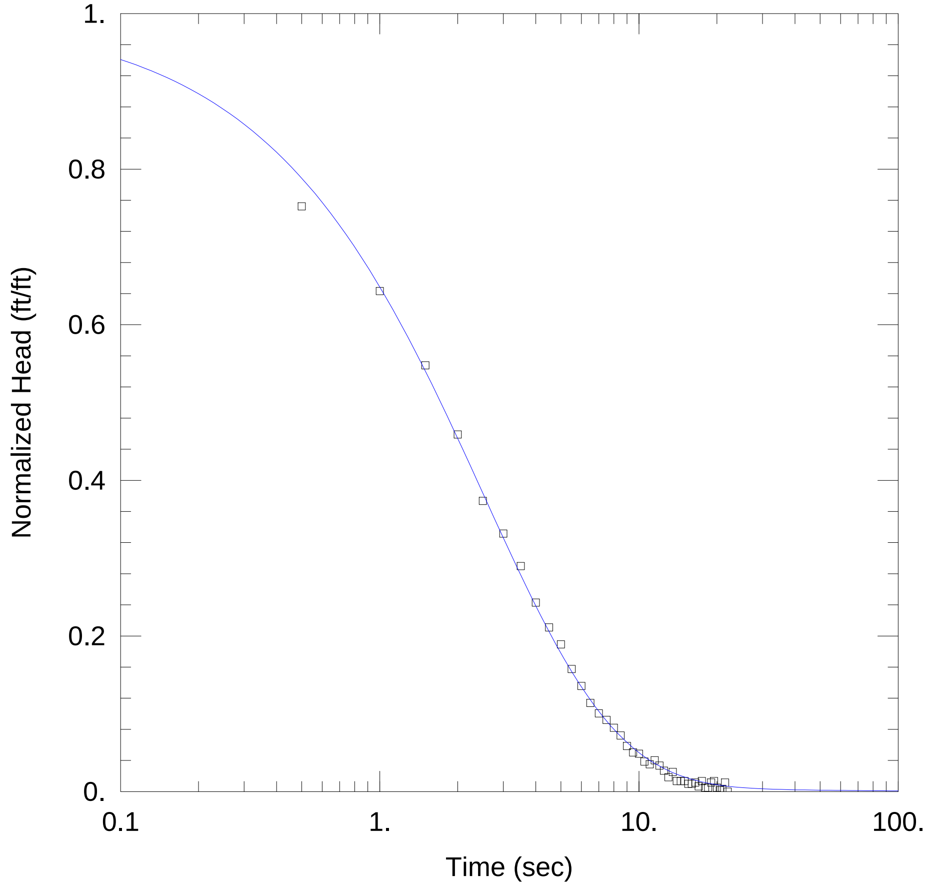
SOLUTION

Aquifer Model: Confined

Solution Method: KGS Model

Kr = 0.01048 cm/sec
Kz/Kr = 0.001

Ss = 6.349E-8 ft^{-1}



10 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\PI-7\Slug_PI-7B_10b(-1)confined.aqt
Date: 02/13/14 Time: 14:06:21

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: PI-7B
Test Date: 08/05/2013

AQUIFER DATA

Saturated Thickness: 39. ft

WELL DATA (PI-7B)

Initial Displacement: 0.597 ft
Total Well Penetration Depth: 20.92 ft
Casing Radius: 0.042 ft

Static Water Column Height: 0. ft
Screen Length: 10. ft
Well Radius: 0.042 ft
Gravel Pack Porosity: 0.

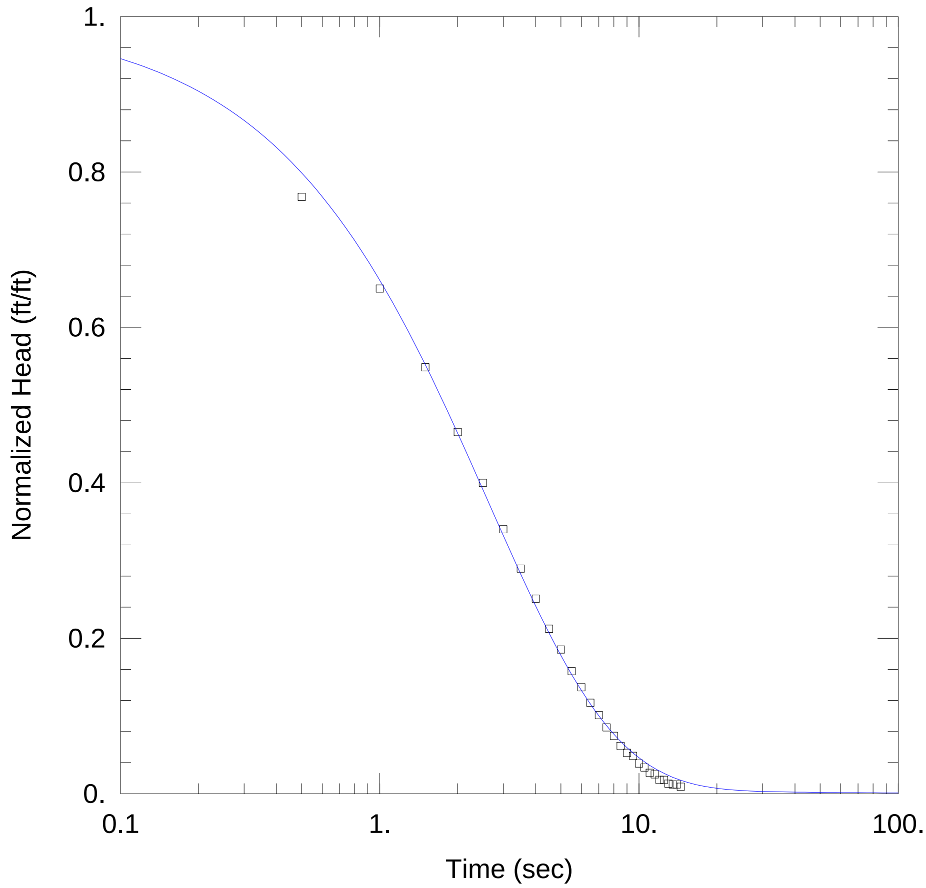
SOLUTION

Aquifer Model: Confined

Solution Method: KGS Model

Kr = 0.006167 cm/sec
Kz/Kr = 1.

Ss = 4.74E-5 ft^{-1}



15 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\PI-7\Slug_PI-7B_15a(-1)confined.aqt
Date: 02/13/14 Time: 14:08:24

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: PI-7B
Test Date: 08/05/2013

AQUIFER DATA

Saturated Thickness: 39. ft

WELL DATA (PI-7B)

Initial Displacement: 1.008 ft
Total Well Penetration Depth: 20.92 ft
Casing Radius: 0.042 ft

Static Water Column Height: 0. ft
Screen Length: 10. ft
Well Radius: 0.042 ft
Gravel Pack Porosity: 0.

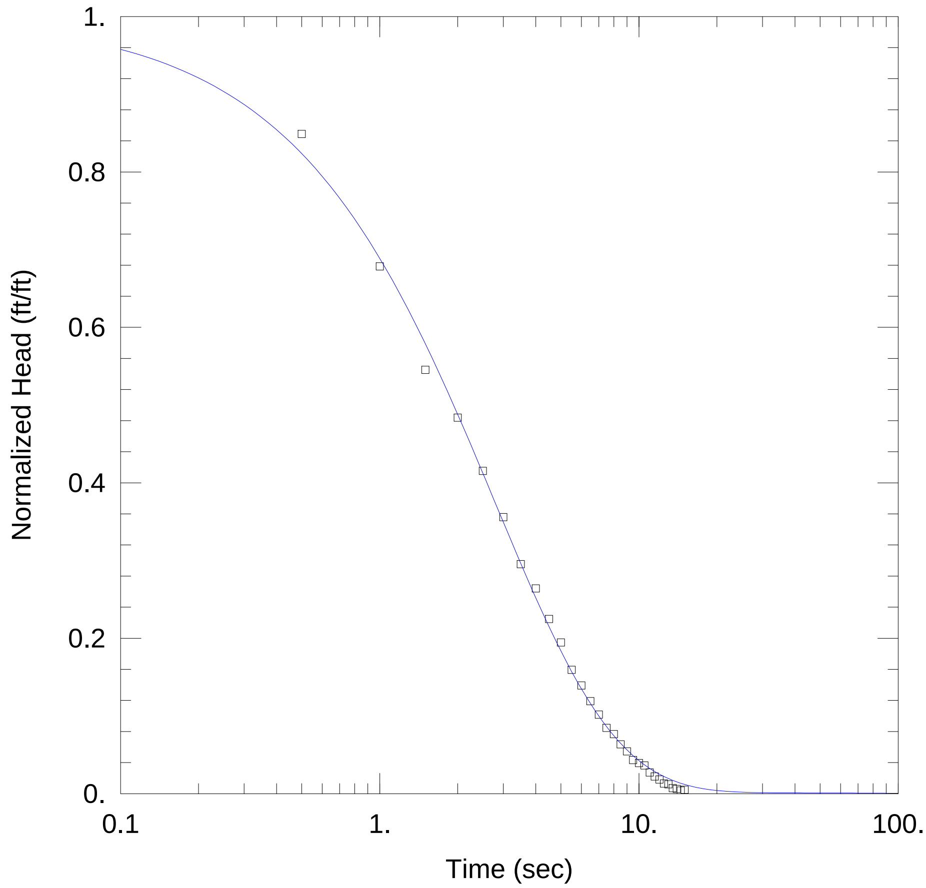
SOLUTION

Aquifer Model: Confined

Solution Method: KGS Model

Kr = 0.005638 cm/sec
Kz/Kr = 1.

Ss = 2.048E-5 ft^{-1}



15 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\PI-7\Slug_PI-7B_15b(-1)confined.aqt
Date: 02/13/14 Time: 14:10:07

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: PI-7B
Test Date: 08/05/2013

AQUIFER DATA

Saturated Thickness: 39. ft

WELL DATA (PI-7B)

Initial Displacement: 0.992 ft
Total Well Penetration Depth: 20.92 ft
Casing Radius: 0.042 ft

Static Water Column Height: 0. ft
Screen Length: 10. ft
Well Radius: 0.042 ft
Gravel Pack Porosity: 0.

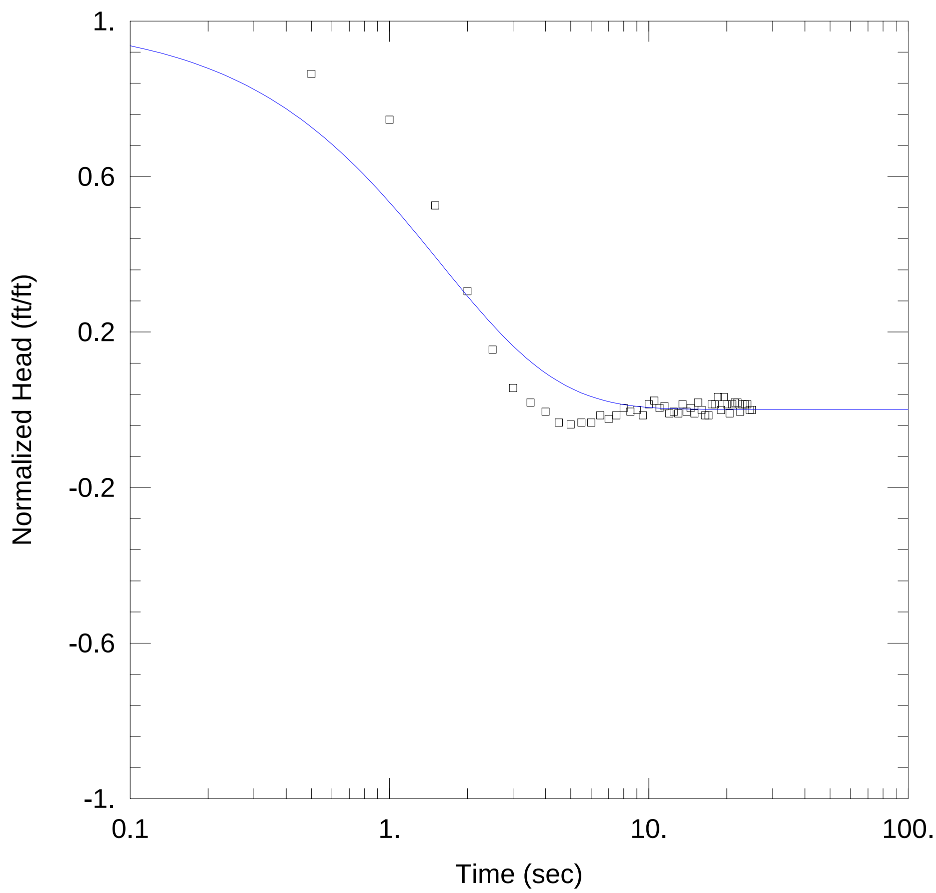
SOLUTION

Aquifer Model: Confined

Solution Method: KGS Model

Kr = 0.009612 cm/sec
Kz/Kr = 0.001

Ss = 2.435E-8 ft^{-1}



5 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\PI-8\Slug_PI_8B_5a(-1)confined.aqt
Date: 02/13/14 Time: 14:13:15

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: PI-8B
Test Date: 08/05/2013

AQUIFER DATA

Saturated Thickness: 42. ft

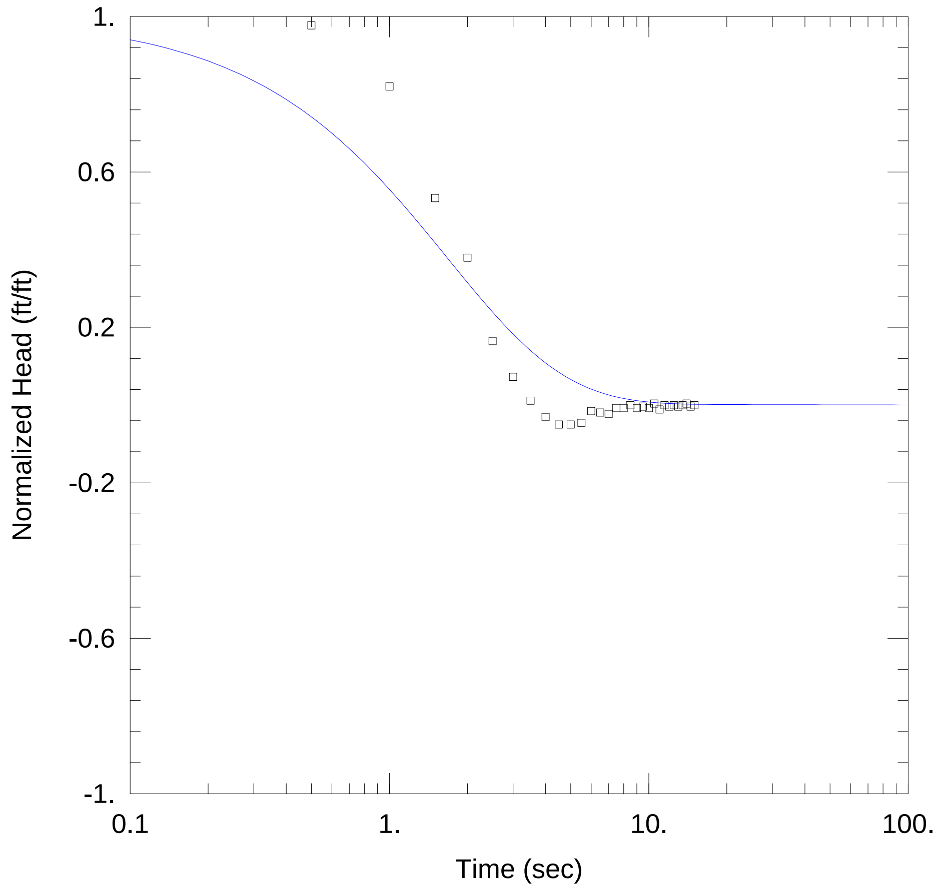
WELL DATA (PI-8B)

Initial Displacement: 0.213 ft
Total Well Penetration Depth: 19. ft
Casing Radius: 0.042 ft
Static Water Column Height: 46. ft
Screen Length: 10. ft
Well Radius: 0.042 ft
Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined
Solution Method: KGS Model

Kr = 0.02189 cm/sec
Kz/Kr = 1.
Ss = 2.381E-12 ft^{-1}



5 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\PI-8\Slug_PI_8B_5b(-1)confined.aqt
Date: 02/13/14 Time: 14:15:15

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: PI-8B
Test Date: 08/05/2013

AQUIFER DATA

Saturated Thickness: 42. ft

WELL DATA (PI-8B)

Initial Displacement: 0.2175 ft
Total Well Penetration Depth: 19. ft
Casing Radius: 0.042 ft

Static Water Column Height: 46. ft
Screen Length: 10. ft
Well Radius: 0.042 ft
Gravel Pack Porosity: 0.

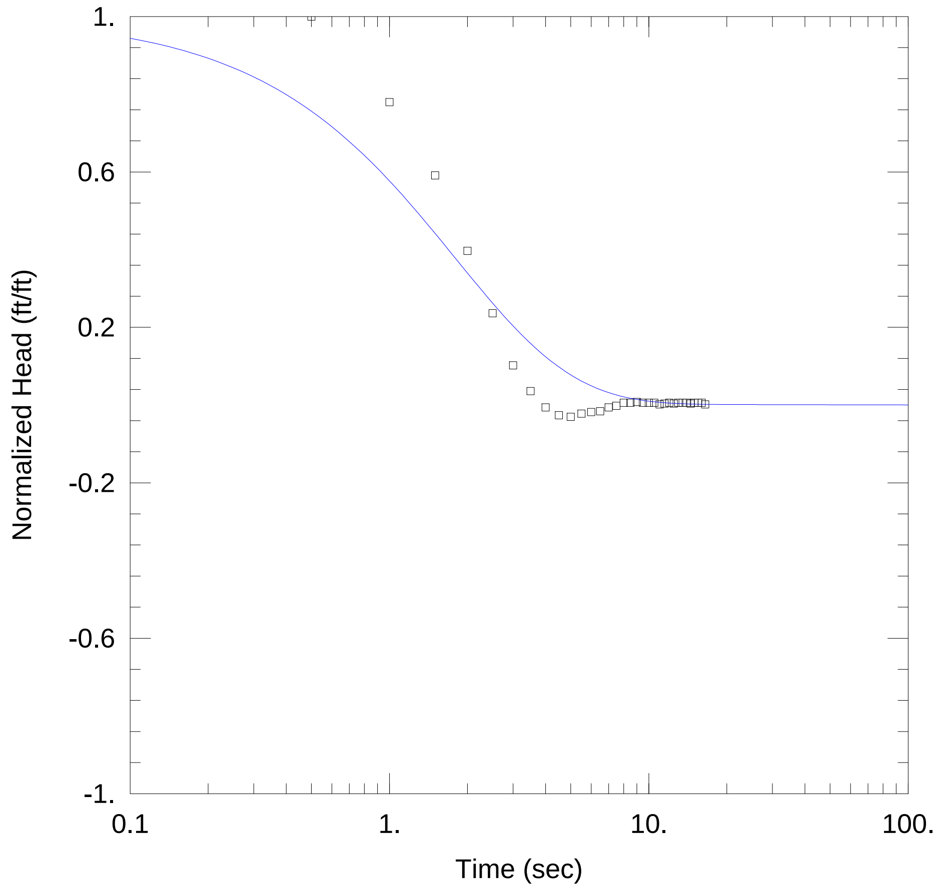
SOLUTION

Aquifer Model: Confined

Solution Method: KGS Model

Kr = 0.02007 cm/sec
Kz/Kr = 1.

Ss = 2.381E-12 ft^{-1}



10 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\PI-8\Slug_PI_8B_10a(-1)confined.aqt
Date: 02/13/14 Time: 14:16:42

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: PI-8B
Test Date: 08/05/2013

AQUIFER DATA

Saturated Thickness: 42. ft

WELL DATA (PI-8B)

Initial Displacement: 0.499 ft
Total Well Penetration Depth: 19. ft
Casing Radius: 0.042 ft

Static Water Column Height: 46. ft
Screen Length: 10. ft
Well Radius: 0.042 ft
Gravel Pack Porosity: 0.

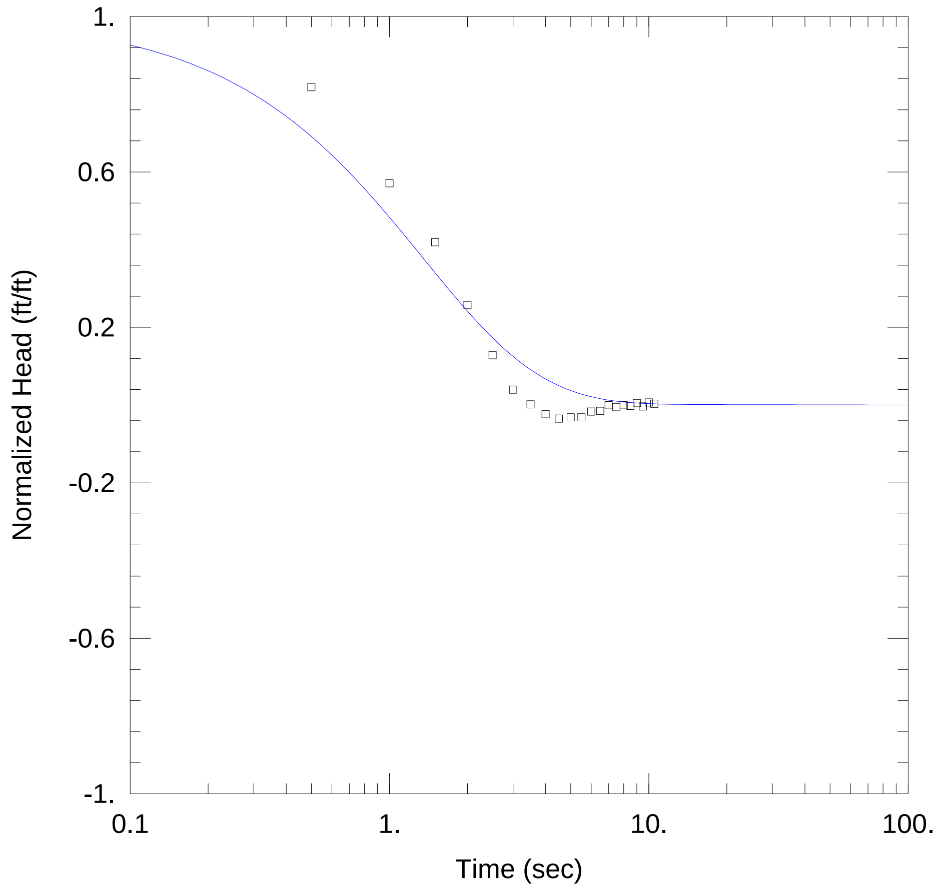
SOLUTION

Aquifer Model: Confined

Solution Method: KGS Model

Kr = 0.01626 cm/sec
Kz/Kr = 1.

Ss = 2.381E-12 ft^{-1}



10 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\PI-8\Slug_PI_8B_10b(-1)confined.aqt
Date: 02/13/14 Time: 14:18:06

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: PI-8B
Test Date: 08/05/2013

AQUIFER DATA

Saturated Thickness: 42. ft

WELL DATA (PI-8B)

Initial Displacement: 0.505 ft
Total Well Penetration Depth: 19. ft
Casing Radius: 0.042 ft

Static Water Column Height: 46. ft
Screen Length: 10. ft
Well Radius: 0.042 ft
Gravel Pack Porosity: 0.

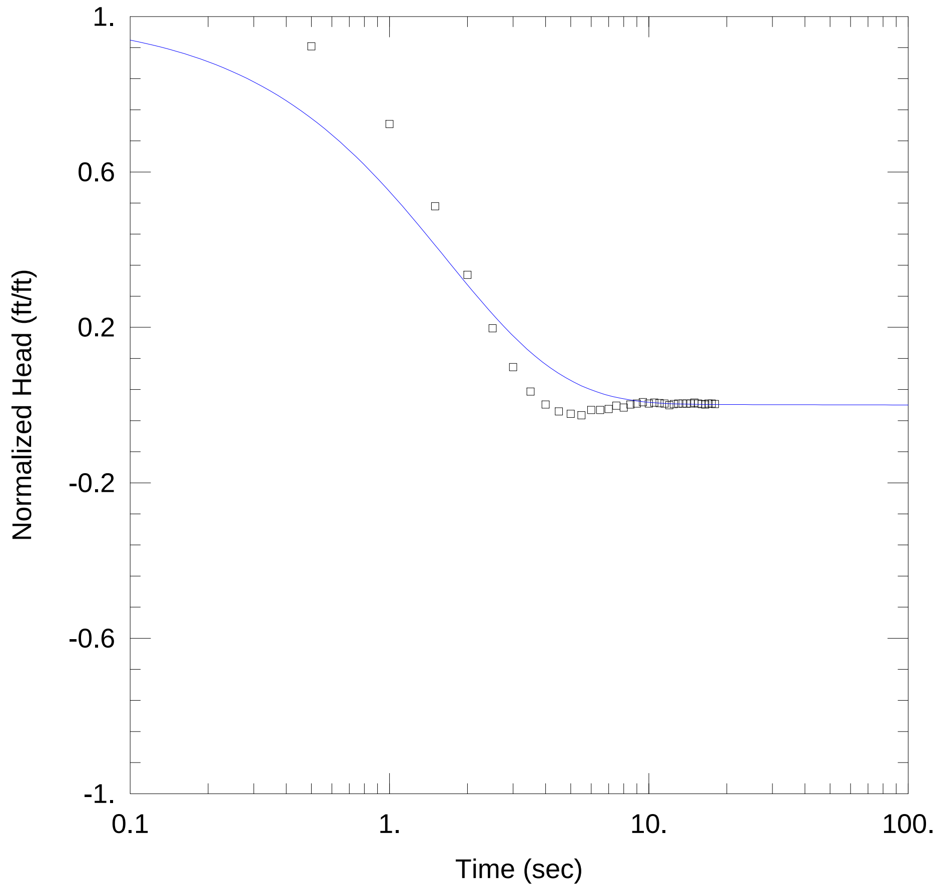
SOLUTION

Aquifer Model: Confined

Solution Method: KGS Model

Kr = 0.02137 cm/sec
Kz/Kr = 1.

Ss = 2.381E-12 ft^{-1}



15 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\PI-8\Slug_PI_8B_15a(-1)confined.aqt
Date: 02/13/14 Time: 14:20:17

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: PI-8B
Test Date: 08/05/2013

AQUIFER DATA

Saturated Thickness: 42. ft

WELL DATA (PI-8B)

Initial Displacement: 0.809 ft
Total Well Penetration Depth: 19. ft
Casing Radius: 0.042 ft

Static Water Column Height: 46. ft
Screen Length: 10. ft
Well Radius: 0.042 ft
Gravel Pack Porosity: 0.

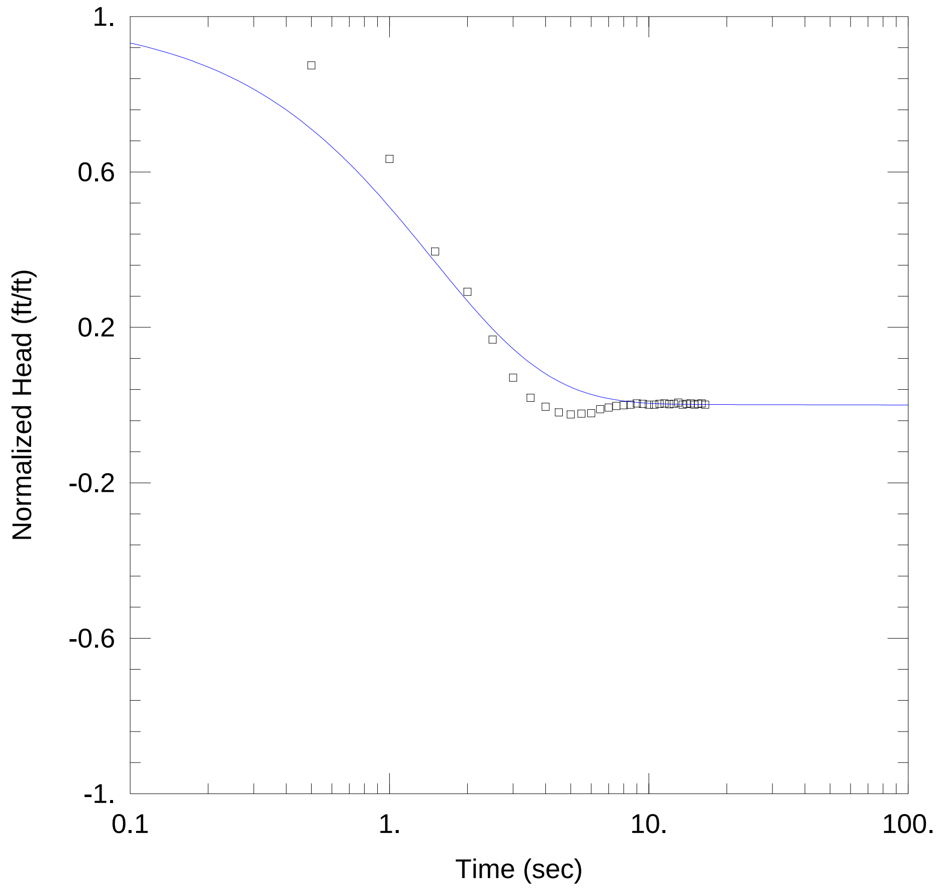
SOLUTION

Aquifer Model: Confined

Solution Method: KGS Model

Kr = 0.01638 cm/sec
Kz/Kr = 1.

Ss = 2.381E-12 ft^{-1}



15 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\PI-8\Slug_PI_8B_15b(-1)confined.aqt
Date: 02/13/14 Time: 14:21:56

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: PI-8B
Test Date: 08/05/2013

AQUIFER DATA

Saturated Thickness: 42. ft

WELL DATA (PI-8B)

Initial Displacement: 0.8008 ft
Total Well Penetration Depth: 19. ft
Casing Radius: 0.042 ft

Static Water Column Height: 46. ft
Screen Length: 10. ft
Well Radius: 0.042 ft
Gravel Pack Porosity: 0.

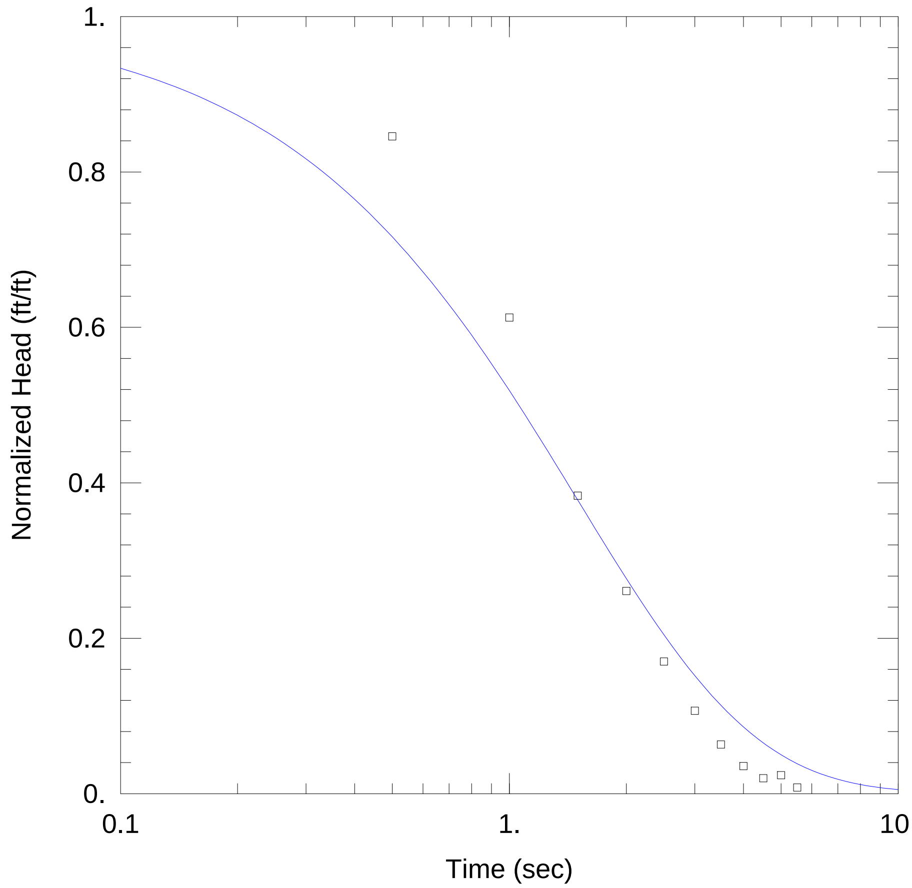
SOLUTION

Aquifer Model: Confined

Solution Method: KGS Model

Kr = 0.01868 cm/sec
Kz/Kr = 1.

Ss = 2.381E-12 ft^{-1}



5 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\PI-9\Slug_PI_9B_5a(-1)confined.aqt
Date: 02/13/14 Time: 14:24:50

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: PI-9B
Test Date: 08/05/2013

AQUIFER DATA

Saturated Thickness: 40. ft

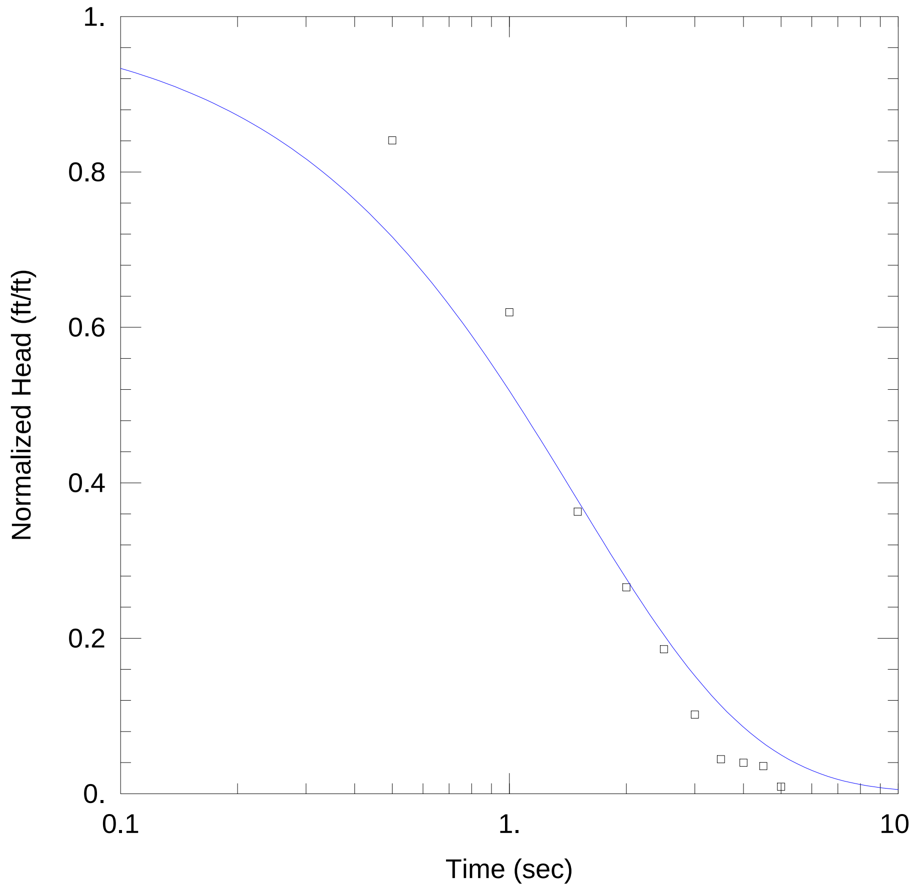
WELL DATA (PI-9B)

Initial Displacement: 0.253 ft
Total Well Penetration Depth: 17.78 ft
Casing Radius: 0.042 ft
Static Water Column Height: 0. ft
Screen Length: 10. ft
Well Radius: 0.042 ft
Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined
Solution Method: KGS Model

Kr = 0.01949 cm/sec
Kz/Kr = 1.
Ss = 2.5E-12 ft^{-1}



5 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\PI-9\Slug_PI_9B_5b(-1)confined.aqt
Date: 02/13/14 Time: 14:26:54

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: PI-9B
Test Date: 08/05/2013

AQUIFER DATA

Saturated Thickness: 40. ft

WELL DATA (PI-9B)

Initial Displacement: 0.226 ft
Total Well Penetration Depth: 17.78 ft
Casing Radius: 0.042 ft

Static Water Column Height: 0. ft
Screen Length: 10. ft
Well Radius: 0.042 ft
Gravel Pack Porosity: 0.

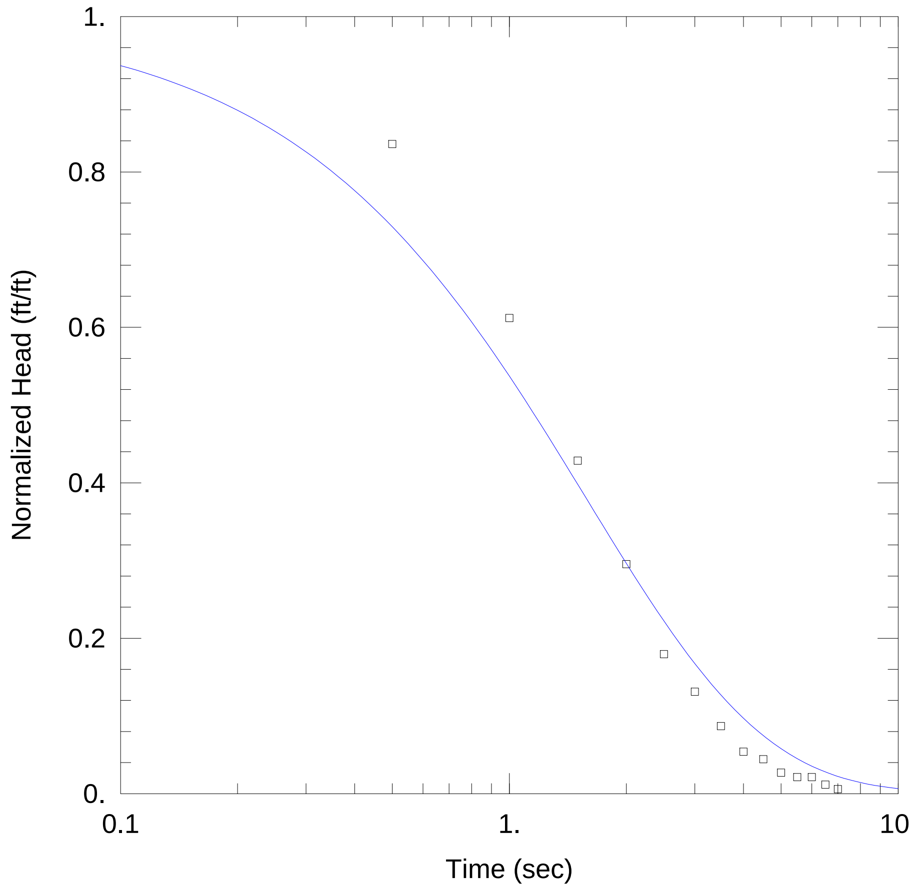
SOLUTION

Aquifer Model: Confined

Solution Method: KGS Model

Kr = 0.02189 cm/sec
Kz/Kr = 1.

Ss = 2.5E-12 ft^{-1}



10 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\PI-9\Slug_PI_9B_10a(-1)confined.aqt
Date: 02/13/14 Time: 14:29:24

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: PI-9B
Test Date: 08/05/2013

AQUIFER DATA

Saturated Thickness: 40. ft

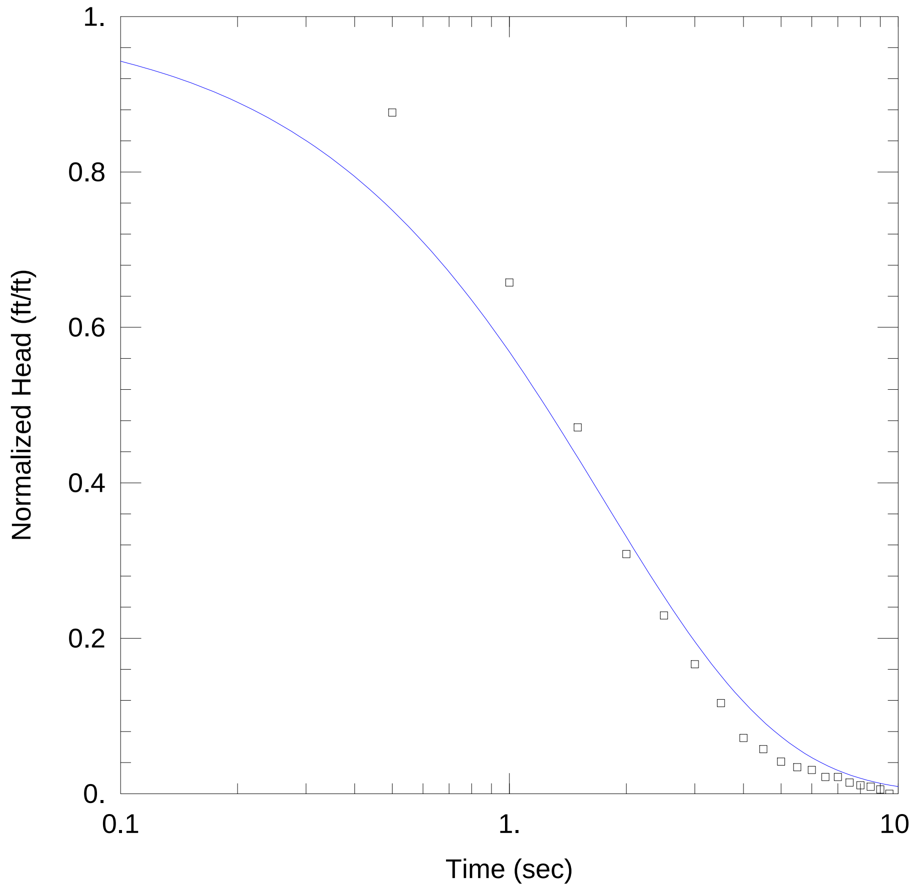
WELL DATA (PI-9B)

Initial Displacement: 0.518 ft
Total Well Penetration Depth: 17.78 ft
Casing Radius: 0.042 ft
Static Water Column Height: 0. ft
Screen Length: 10. ft
Well Radius: 0.042 ft
Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined
Solution Method: KGS Model

Kr = 0.01796 cm/sec
Kz/Kr = 1.
Ss = 2.5E-12 ft^{-1}



10 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\PI-9\Slug_PI_9B_10b(-1)confined.aqt
Date: 02/13/14 Time: 14:32:18

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: PI-9B
Test Date: 08/05/2013

AQUIFER DATA

Saturated Thickness: 40. ft

WELL DATA (PI-9B)

Initial Displacement: 0.558 ft
Total Well Penetration Depth: 17.78 ft
Casing Radius: 0.042 ft

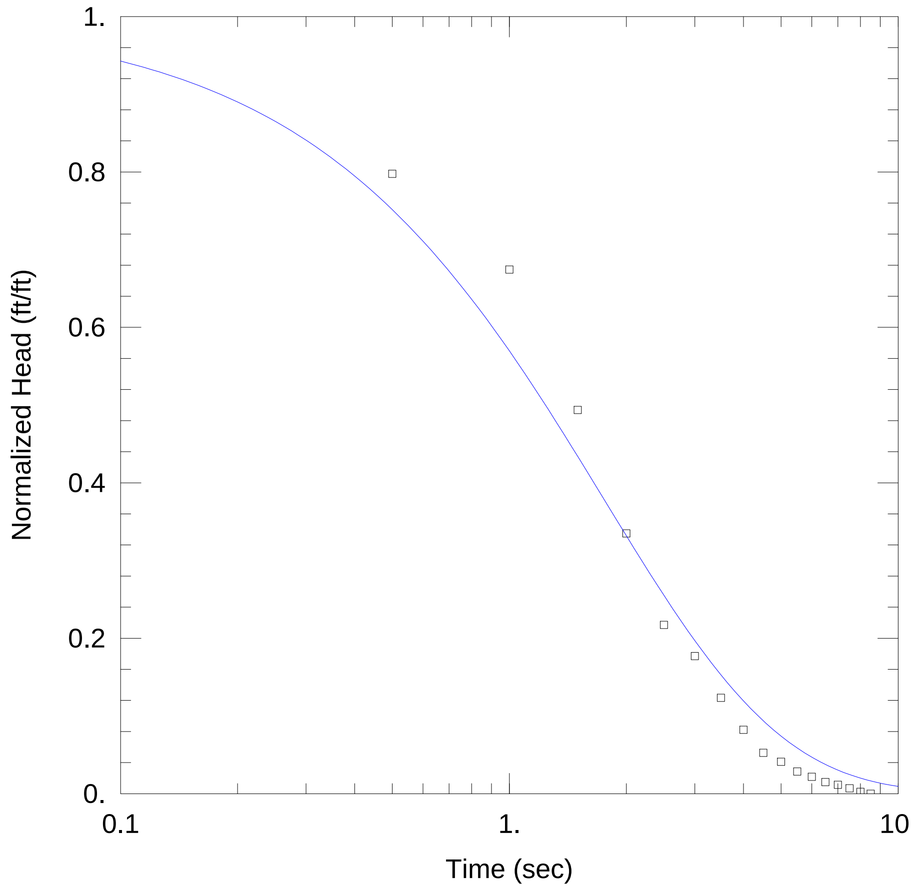
Static Water Column Height: 0. ft
Screen Length: 10. ft
Well Radius: 0.042 ft
Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined
Solution Method: KGS Model

Kr = 0.0151 cm/sec
Kz/Kr = 1.

Ss = 2.5E-12 ft^{-1}



15 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\PI-9\Slug_PI_9B_15a(-1)confined.aqt
Date: 02/13/14 Time: 14:34:22

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: PI-9B
Test Date: 08/05/2013

AQUIFER DATA

Saturated Thickness: 40. ft

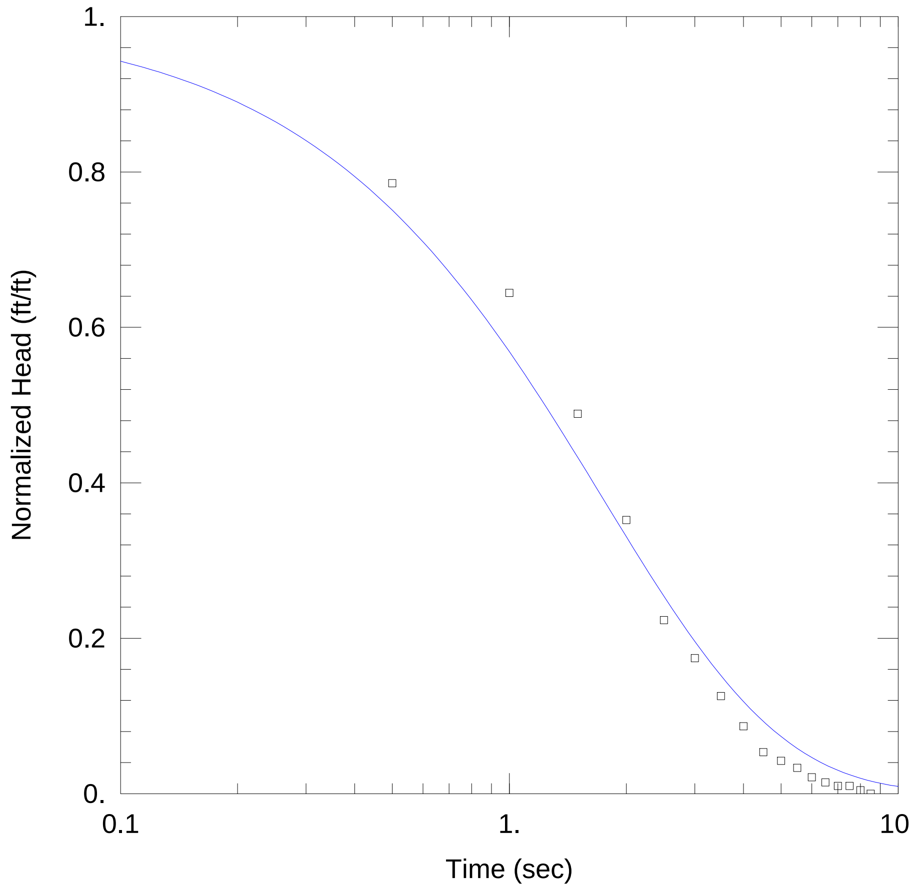
WELL DATA (PI-9B)

Initial Displacement: 0.875 ft
Total Well Penetration Depth: 17.78 ft
Casing Radius: 0.042 ft
Static Water Column Height: 0. ft
Screen Length: 10. ft
Well Radius: 0.042 ft
Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined
Solution Method: KGS Model

Kr = 0.01438 cm/sec
Kz/Kr = 1.
Ss = 2.5E-12 ft^{-1}



15 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\PI-9\Slug_PI_9B_15b(-1)confined.aqt
Date: 02/13/14 Time: 14:37:26

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: PI-9B
Test Date: 08/05/2013

AQUIFER DATA

Saturated Thickness: 40. ft

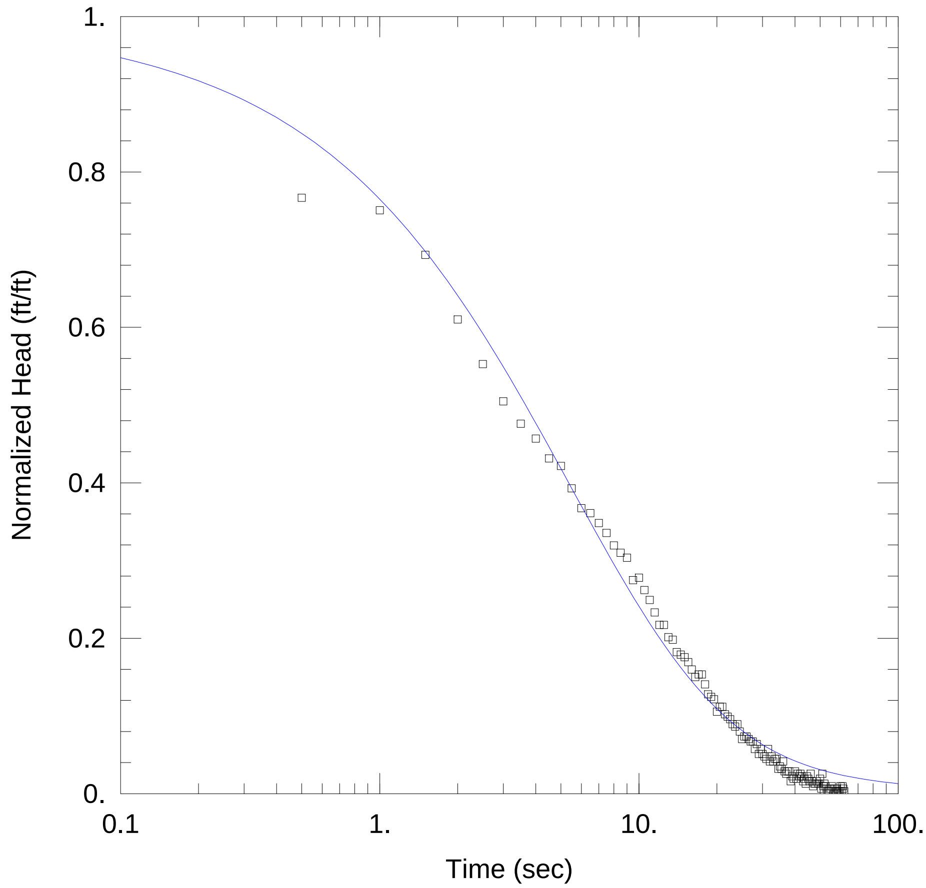
WELL DATA (PI-9B)

Initial Displacement: 0.9 ft
Total Well Penetration Depth: 17.78 ft
Casing Radius: 0.042 ft
Static Water Column Height: 0. ft
Screen Length: 10. ft
Well Radius: 0.042 ft
Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined
Solution Method: KGS Model

Kr = 0.01402 cm/sec
Kz/Kr = 1.
Ss = 2.5E-12 ft^{-1}



5 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\PI-9\Slug_PI_9C_5a(-1)confined.aqt
Date: 02/13/14 Time: 17:31:10

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: PI-9C
Test Date: 08/05/2013

AQUIFER DATA

Saturated Thickness: 8. ft

WELL DATA (PI-9C)

Initial Displacement: 0.313 ft
Total Well Penetration Depth: 10. ft
Casing Radius: 0.042 ft

Static Water Column Height: 0. ft
Screen Length: 10. ft
Well Radius: 0.042 ft
Gravel Pack Porosity: 0.

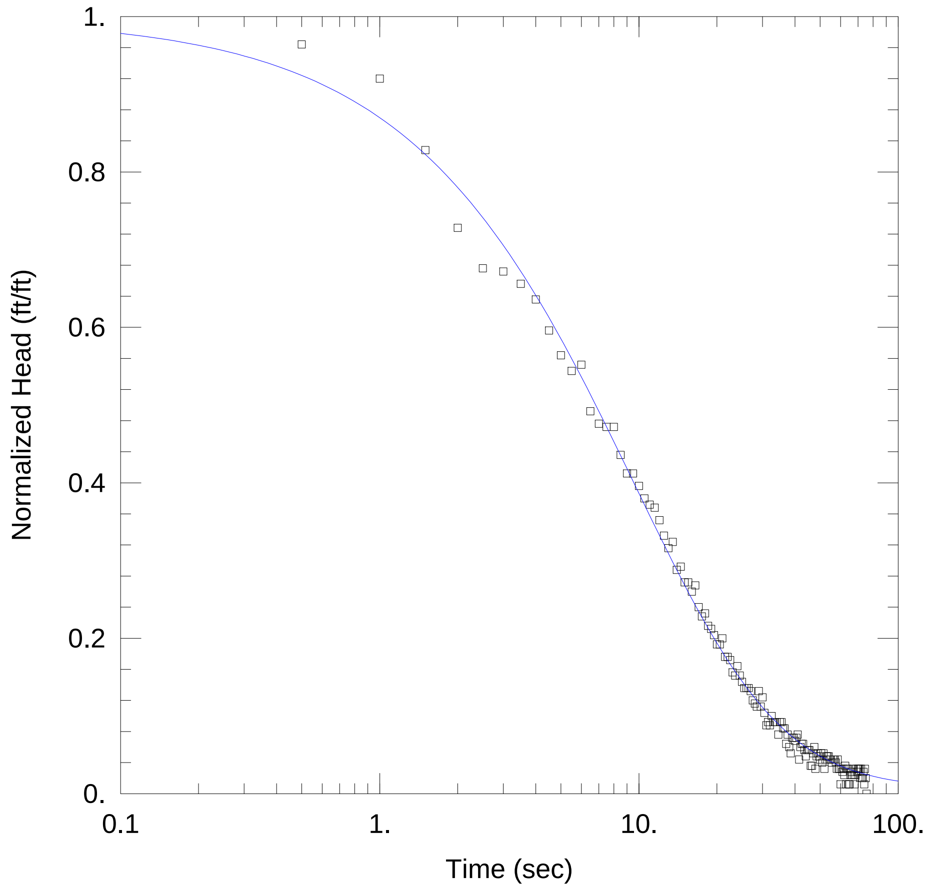
SOLUTION

Aquifer Model: Confined

Solution Method: KGS Model

Kr = 0.002056 cm/sec
Kz/Kr = 1.

Ss = 0.001816 ft^{-1}



5 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\PI-9\Slug_PI_9C_5b(-1)confined.aqt
Date: 02/13/14 Time: 17:33:23

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: PI-9C
Test Date: 08/05/2013

AQUIFER DATA

Saturated Thickness: 8. ft

WELL DATA (PI-9C)

Initial Displacement: 0.25 ft
Total Well Penetration Depth: 10. ft
Casing Radius: 0.042 ft

Static Water Column Height: 0. ft
Screen Length: 10. ft
Well Radius: 0.042 ft
Gravel Pack Porosity: 0.

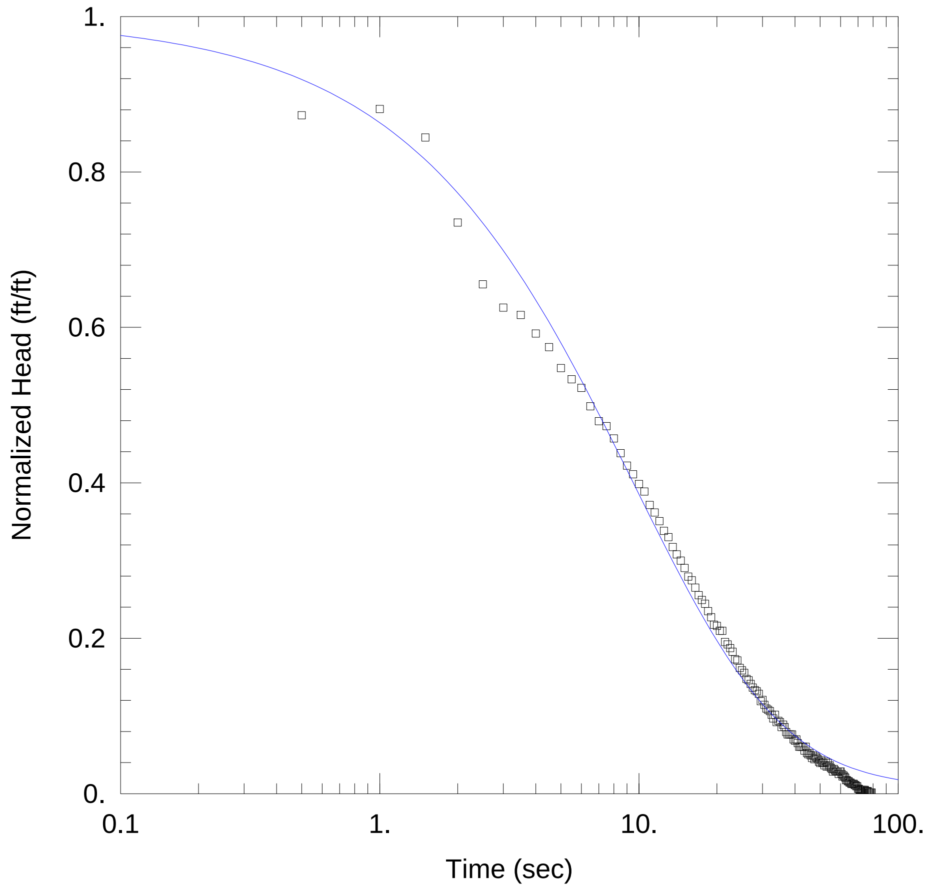
SOLUTION

Aquifer Model: Confined

Solution Method: KGS Model

Kr = 0.002344 cm/sec
Kz/Kr = 1.

Ss = 0.0001124 ft^{-1}



10 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\PI-9\Slug_PI_9C_10a(-1)confined.aqt
Date: 02/13/14 Time: 17:36:07

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: PI-9C
Test Date: 08/05/2013

AQUIFER DATA

Saturated Thickness: 8. ft

WELL DATA (PI-9C)

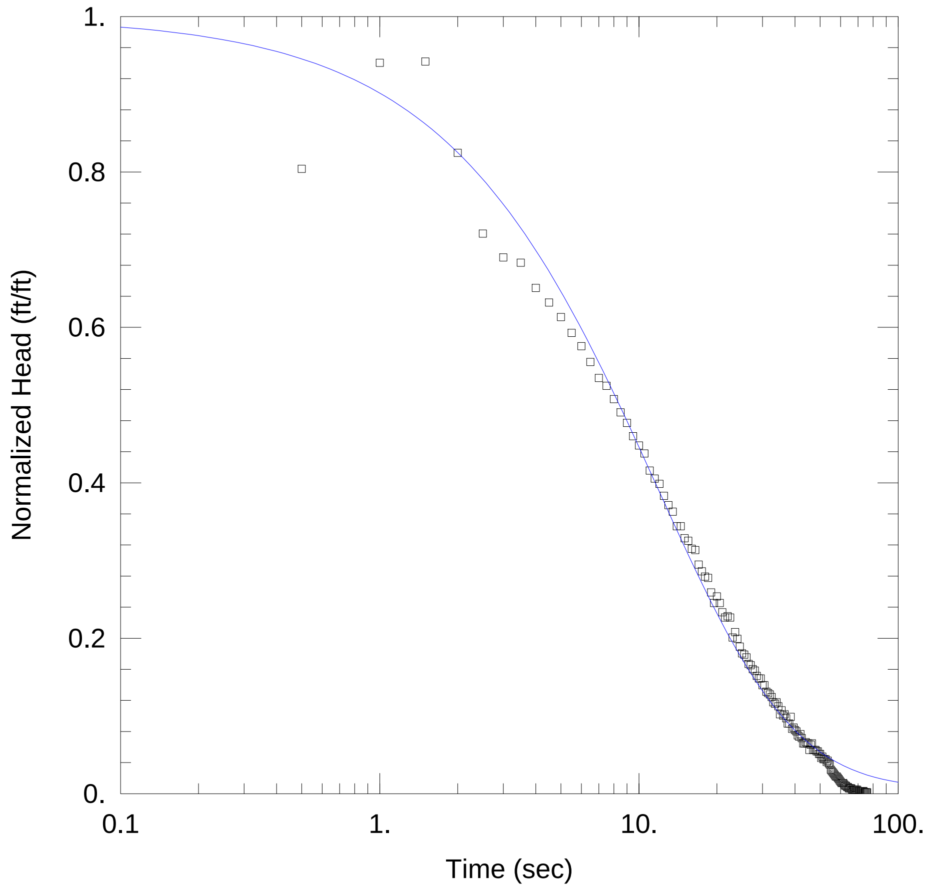
Initial Displacement: 0.63 ft
Total Well Penetration Depth: 10. ft
Casing Radius: 0.042 ft

Static Water Column Height: 0. ft
Screen Length: 10. ft
Well Radius: 0.042 ft
Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined
Solution Method: KGS Model

Kr = 0.001675 cm/sec
Kz/Kr = 1.
Ss = 0.0002009 ft^{-1}



10 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\PI-9\Slug_PI_9C_10b(-1)confined.aqt
Date: 02/13/14 Time: 17:38:55

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: PI-9C
Test Date: 08/05/2013

AQUIFER DATA

Saturated Thickness: 8. ft

WELL DATA (PI-9C)

Initial Displacement: 0.587 ft
Total Well Penetration Depth: 10. ft
Casing Radius: 0.042 ft

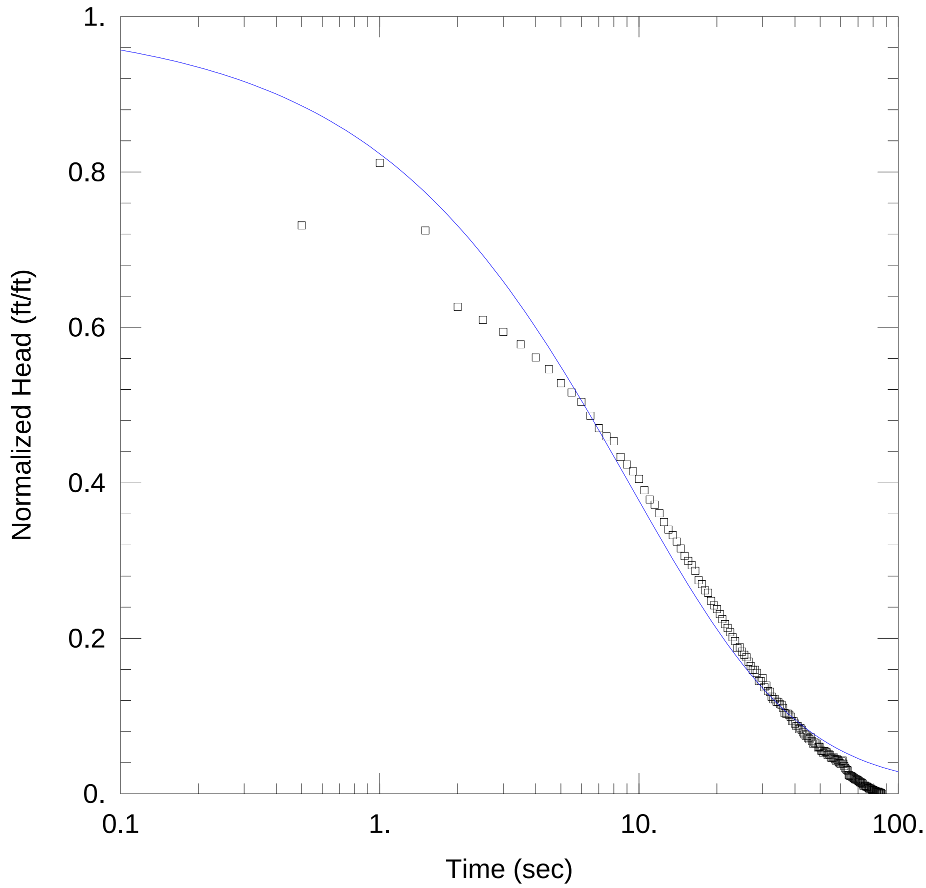
Static Water Column Height: 0. ft
Screen Length: 10. ft
Well Radius: 0.042 ft
Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined
Solution Method: KGS Model

Kr = 0.002365 cm/sec
Kz/Kr = 1.

Ss = 2.912E-6 ft^{-1}



15 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\PI-9\Slug_PI_9C_15a(-1)confined.aqt
Date: 02/13/14 Time: 17:40:26

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: PI-9C
Test Date: 08/05/2013

AQUIFER DATA

Saturated Thickness: 8. ft

WELL DATA (PI-9C)

Initial Displacement: 1.242 ft
Total Well Penetration Depth: 10. ft
Casing Radius: 0.042 ft

Static Water Column Height: 0. ft
Screen Length: 10. ft
Well Radius: 0.042 ft

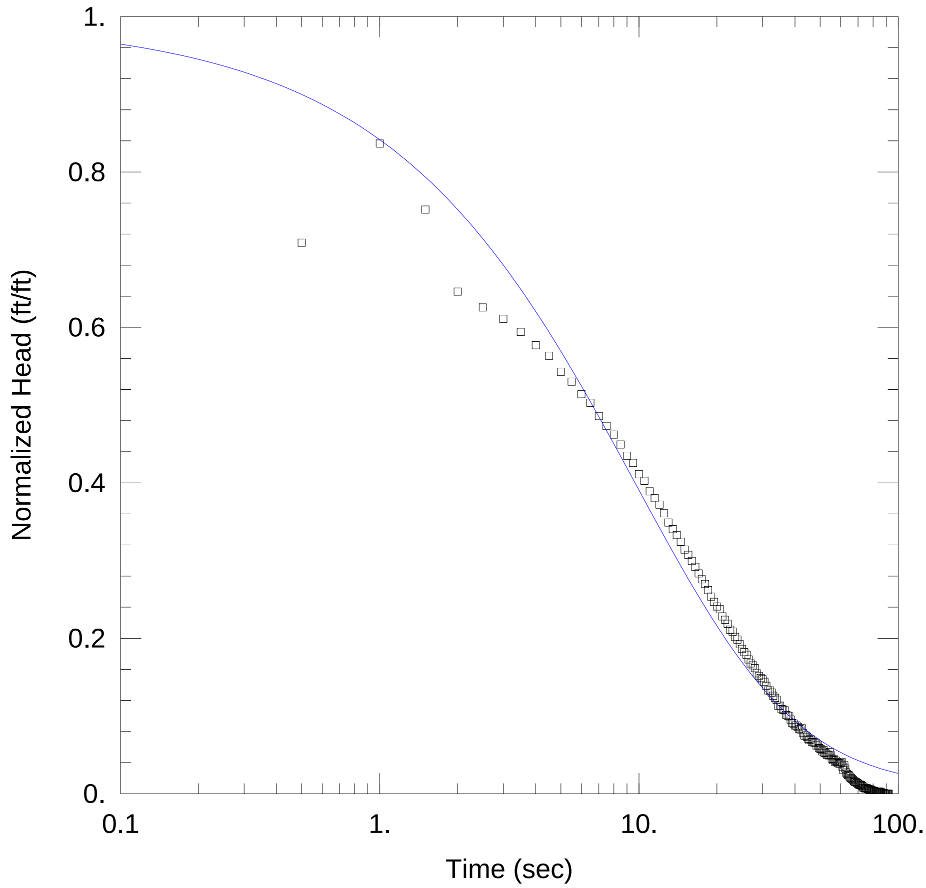
SOLUTION

Aquifer Model: Confined

Solution Method: KGS Model

Kr = 0.0007993 cm/sec
Kz/Kr = 1.

Ss = 0.002368 ft^{-1}



15 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\PI-9\Slug_PI_9C_15b(-1)confined.aqt
Date: 02/13/14 Time: 17:42:00

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: PI-9C
Test Date: 08/05/2013

AQUIFER DATA

Saturated Thickness: 8. ft

WELL DATA (PI-9C)

Initial Displacement: 1.175 ft
Total Well Penetration Depth: 10. ft
Casing Radius: 0.042 ft

Static Water Column Height: 0. ft
Screen Length: 10. ft
Well Radius: 0.042 ft
Gravel Pack Porosity: 0.

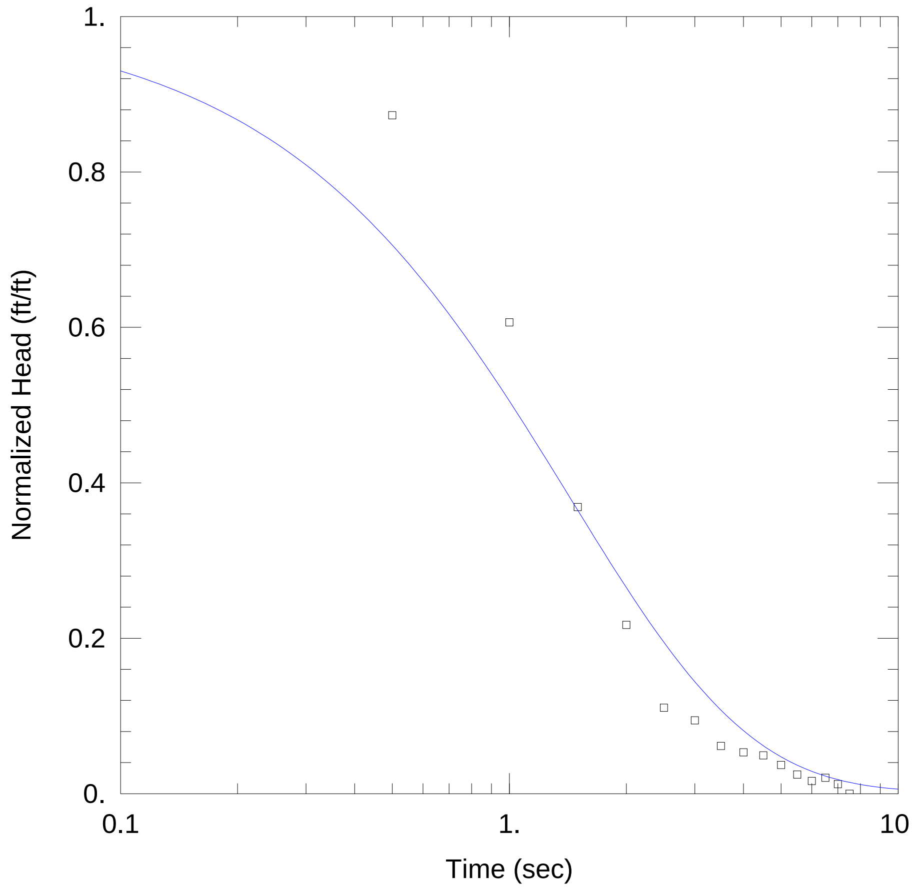
SOLUTION

Aquifer Model: Confined

Solution Method: KGS Model

Kr = 0.0009403 cm/sec
Kz/Kr = 1.

Ss = 0.001244 ft^{-1}



5 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\PI-10\Slug_PI_10B_5a(-1)confined.aqt
Date: 02/13/14 Time: 15:04:05

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: PI-10B
Test Date: 08/05/2013

AQUIFER DATA

Saturated Thickness: 29. ft

WELL DATA (PI-10B)

Initial Displacement: 0.244 ft
Total Well Penetration Depth: 15.69 ft
Casing Radius: 0.042 ft

Static Water Column Height: 0. ft
Screen Length: 10. ft
Well Radius: 0.042 ft
Gravel Pack Porosity: 0.

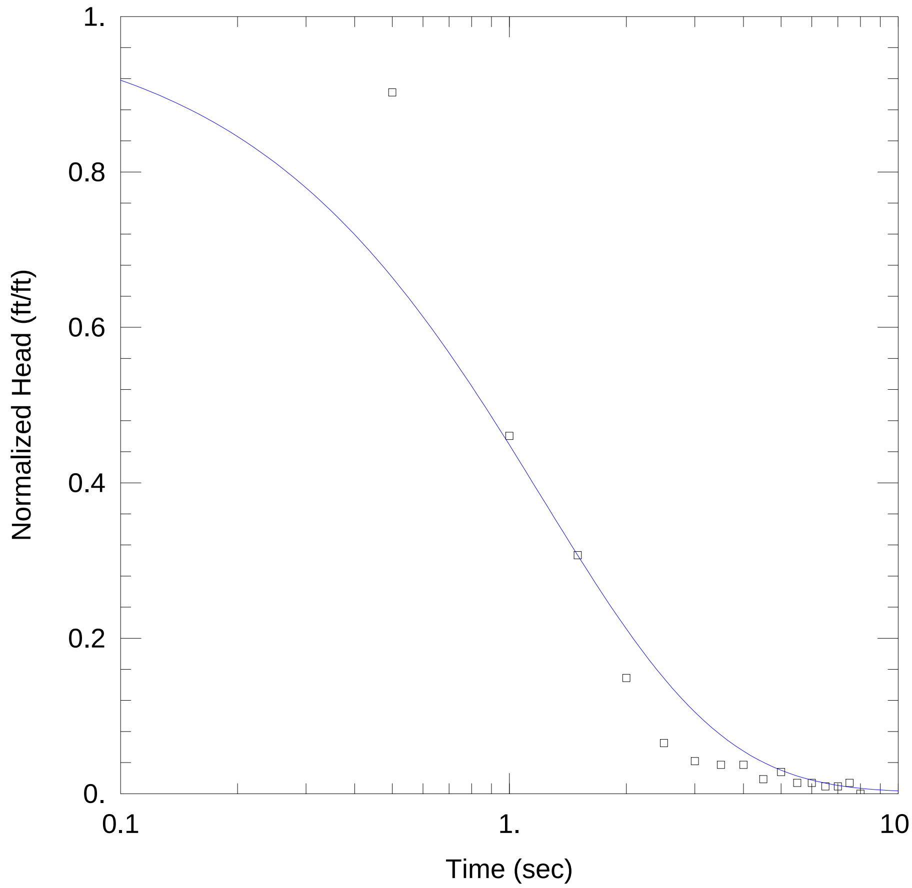
SOLUTION

Aquifer Model: Confined

Solution Method: KGS Model

Kr = 0.02305 cm/sec
Kz/Kr = 1.

Ss = 3.448E-12 ft^{-1}



5 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\PI-10\Slug_PI_10B_5b(-1)confined.aqt
Date: 02/13/14 Time: 15:07:32

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: PI-10B
Test Date: 08/05/2013

AQUIFER DATA

Saturated Thickness: 29. ft

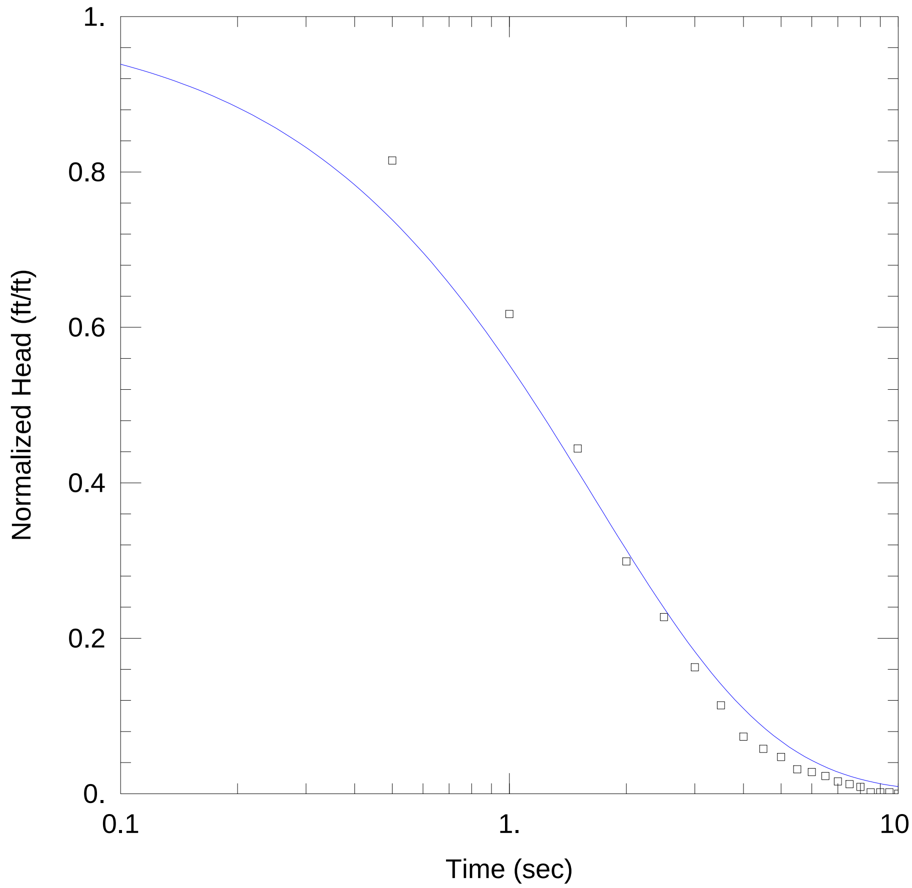
WELL DATA (PI-10B)

Initial Displacement: 0.215 ft
Total Well Penetration Depth: 15.69 ft
Casing Radius: 0.042 ft
Static Water Column Height: 0. ft
Screen Length: 10. ft
Well Radius: 0.042 ft
Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined
Solution Method: KGS Model

Kr = 0.03096 cm/sec
Kz/Kr = 1.
Ss = 3.448E-12 ft^{-1}



10 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\PI-10\Slug_PI_10B_10a(-1)confined.aqt
Date: 02/13/14 Time: 15:09:41

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: PI-10B
Test Date: 08/05/2013

AQUIFER DATA

Saturated Thickness: 29. ft

WELL DATA (PI-10B)

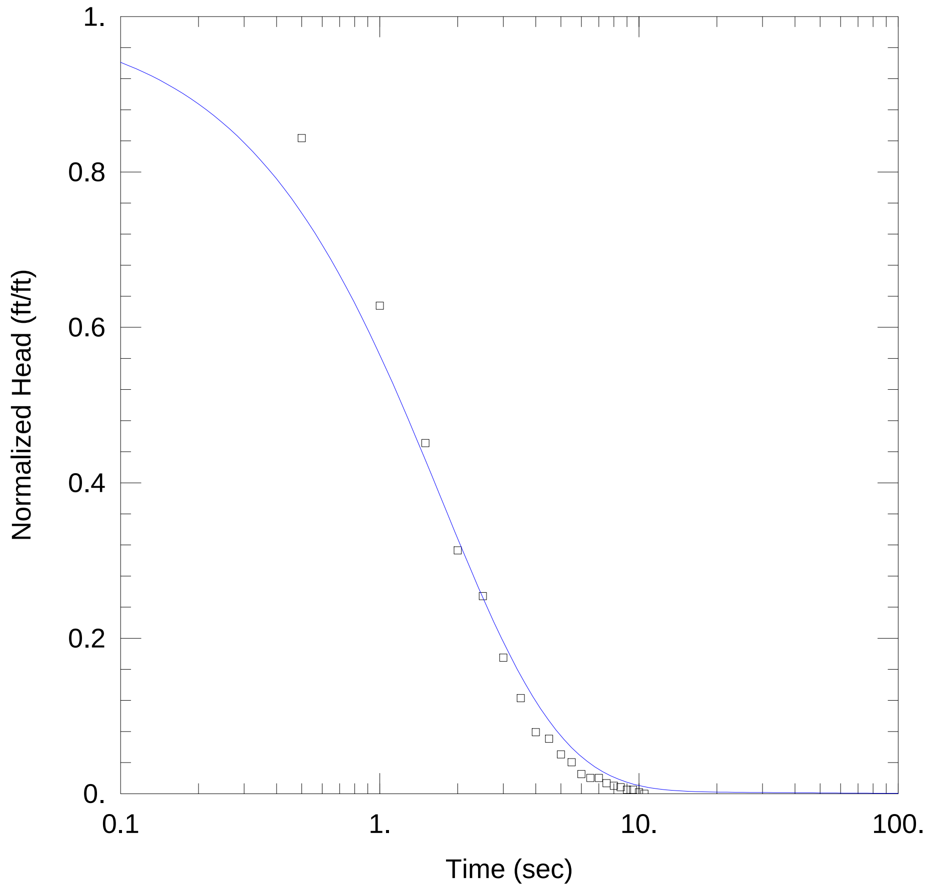
Initial Displacement: 0.572 ft
Total Well Penetration Depth: 15.69 ft
Casing Radius: 0.042 ft

Static Water Column Height: 0. ft
Screen Length: 10. ft
Well Radius: 0.042 ft
Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined
Solution Method: KGS Model

Kr = 0.01697 cm/sec
Kz/Kr = 1.
Ss = 3.448E-12 ft^{-1}



10 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\PI-10\Slug_PI_10B_10b(-1)confined.aqt
Date: 02/13/14 Time: 15:11:17

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: PI-10B
Test Date: 08/05/2013

AQUIFER DATA

Saturated Thickness: 29. ft

WELL DATA (PI-10B)

Initial Displacement: 0.594 ft
Total Well Penetration Depth: 15.69 ft
Casing Radius: 0.042 ft

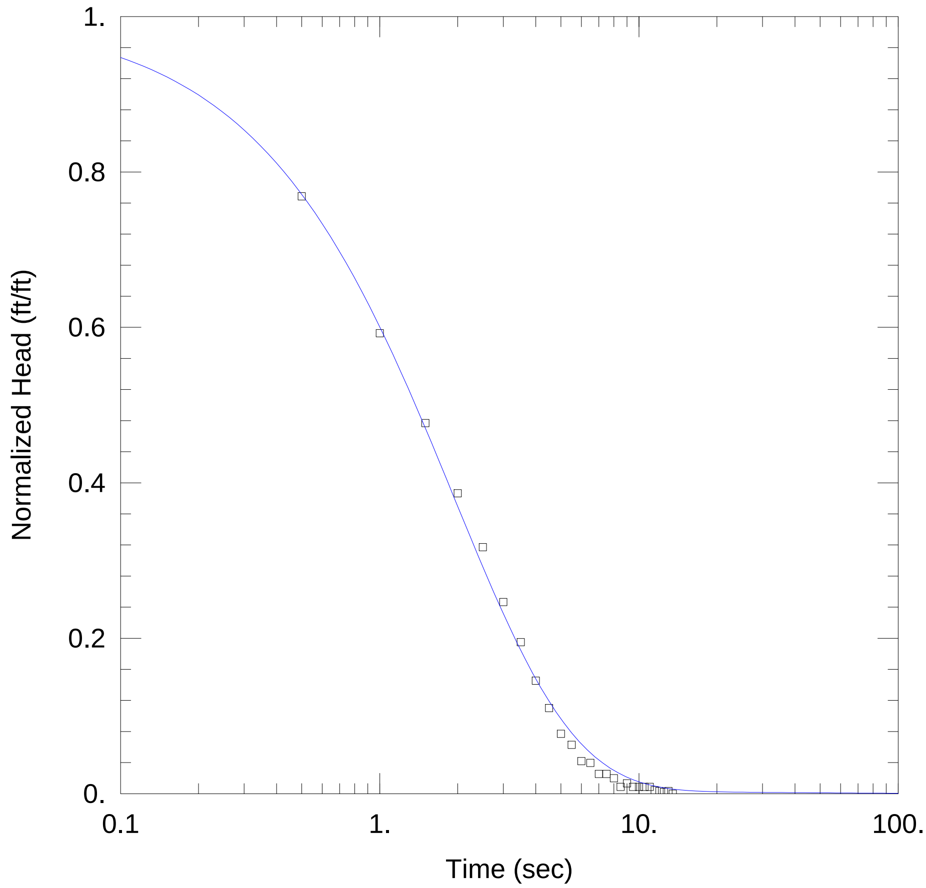
Static Water Column Height: 0. ft
Screen Length: 10. ft
Well Radius: 0.042 ft
Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined
Solution Method: KGS Model

Kr = 0.01566 cm/sec
Kz/Kr = 1.

Ss = 3.448E-12 ft^{-1}



15 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\PI-10\Slug_PI_10B_15a(-1)confined.aqt
Date: 02/13/14 Time: 15:14:25

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: PI-10B
Test Date: 08/05/2013

AQUIFER DATA

Saturated Thickness: 29. ft

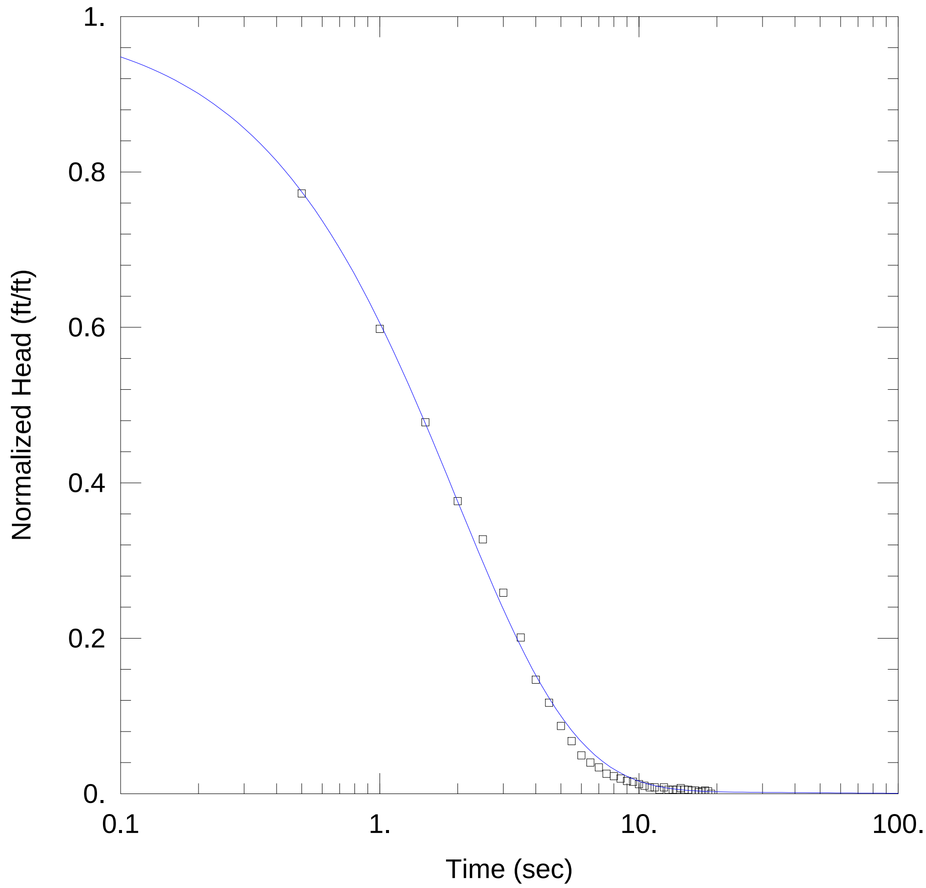
WELL DATA (PI-10B)

Initial Displacement: 0.908 ft
Total Well Penetration Depth: 15.69 ft
Casing Radius: 0.042 ft
Static Water Column Height: 0. ft
Screen Length: 10. ft
Well Radius: 0.042 ft
Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined
Solution Method: KGS Model

Kr = 0.01366 cm/sec
Kz/Kr = 1.
Ss = 3.448E-12 ft^{-1}



15 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\PI-10\Slug_PI_10B_15b(-1)confined.aqt
Date: 02/13/14 Time: 15:16:12

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: PI-10B
Test Date: 08/05/2013

AQUIFER DATA

Saturated Thickness: 29. ft

WELL DATA (PI-10B)

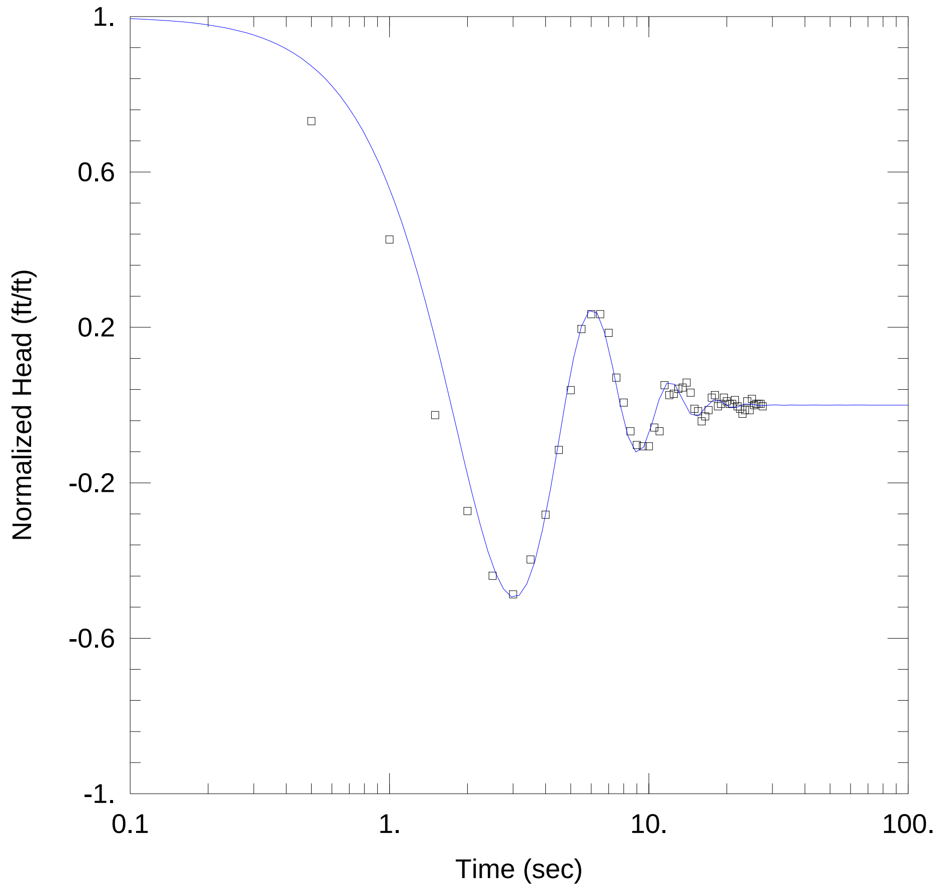
Initial Displacement: 0.975 ft
Total Well Penetration Depth: 15.69 ft
Casing Radius: 0.042 ft

Static Water Column Height: 0. ft
Screen Length: 10. ft
Well Radius: 0.042 ft
Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined
Solution Method: KGS Model

Kr = 0.01247 cm/sec
Kz/Kr = 1.
Ss = 3.448E-12 ft^{-1}



5 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\99-1\Slug_RI_99-1_5a(-1)confined.aqt
Date: 02/12/14
Time: 16:05:46

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: RI MW 99-1
Test Date: 08/06/2013

AQUIFER DATA

Saturated Thickness: 40. ft
Anisotropy Ratio (Kz/Kr): 1.

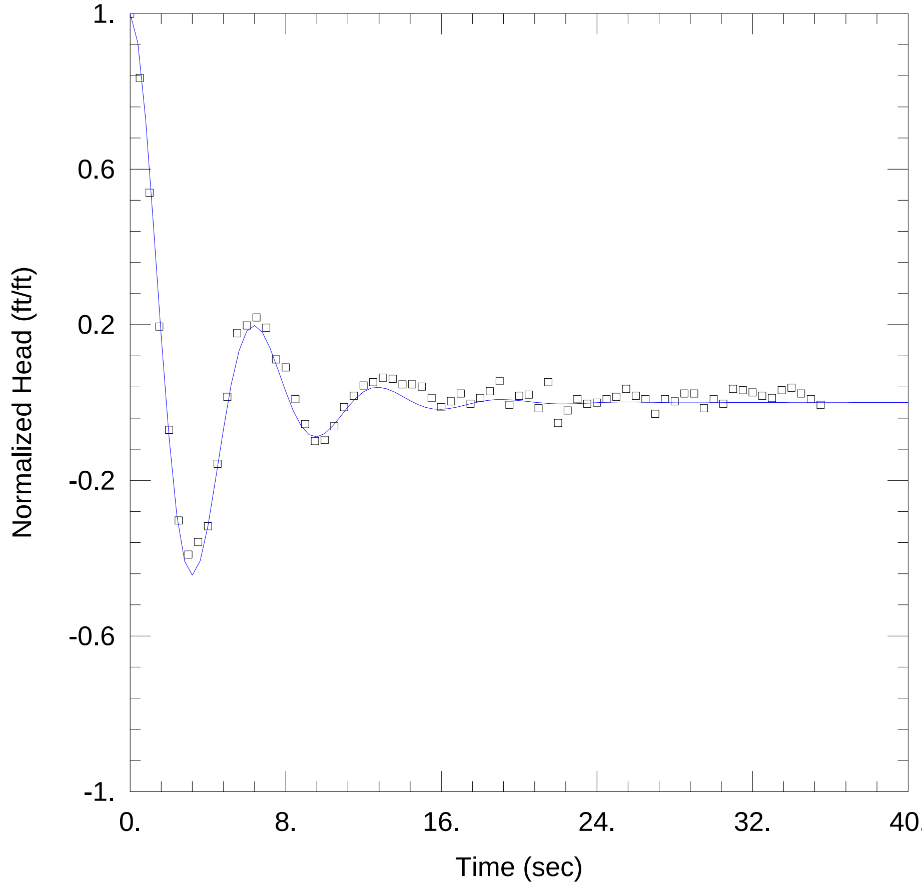
WELL DATA (RI-99-1)

Initial Displacement: 0.312 ft
Total Well Penetration Depth: 24. ft
Casing Radius: 0.042 ft
Static Water Column Height: 0. ft
Screen Length: 5. ft
Well Radius: 0.208 ft

SOLUTION

Aquifer Model: Confined
Solution Method: McElwee-Zenner

K = 0.04194 cm/sec
A = 0.
ß = 28.38 ft
v(0) = 0. cm/sec



5 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\99-1\Slug_RI_99-1_5b(-1)confined.aqt
Date: 02/12/14 Time: 16:03:57

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: RI MW 99-1
Test Date: 08/06/2013

AQUIFER DATA

Saturated Thickness: 40. ft
Anisotropy Ratio (Kz/Kr): 1.

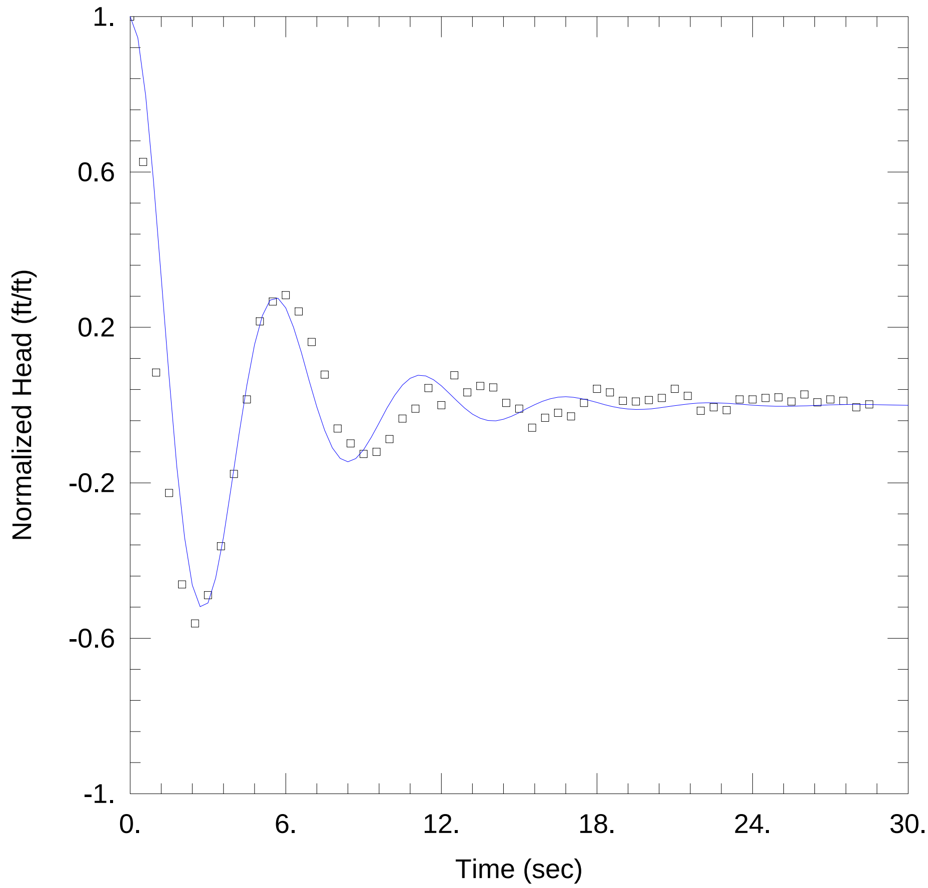
WELL DATA (RI-99-1)

Initial Displacement: 0.343 ft
Static Water Column Height: 0. ft
Total Well Penetration Depth: 24. ft
Screen Length: 5. ft
Casing Radius: 0.042 ft
Well Radius: 0.208 ft

SOLUTION

Aquifer Model: Confined
Solution Method: McElwee-Zenner

K = 0.03503 cm/sec
ß = 30.95 ft
A = 0.
v(0) = 0. cm/sec



10 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\99-1\Slug_RI_99-1_10a(-1)confined.aqt
Date: 02/12/14 Time: 16:08:31

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: RI MW 99-1
Test Date: 08/06/2013

AQUIFER DATA

Saturated Thickness: 40. ft
Anisotropy Ratio (Kz/Kr): 1.

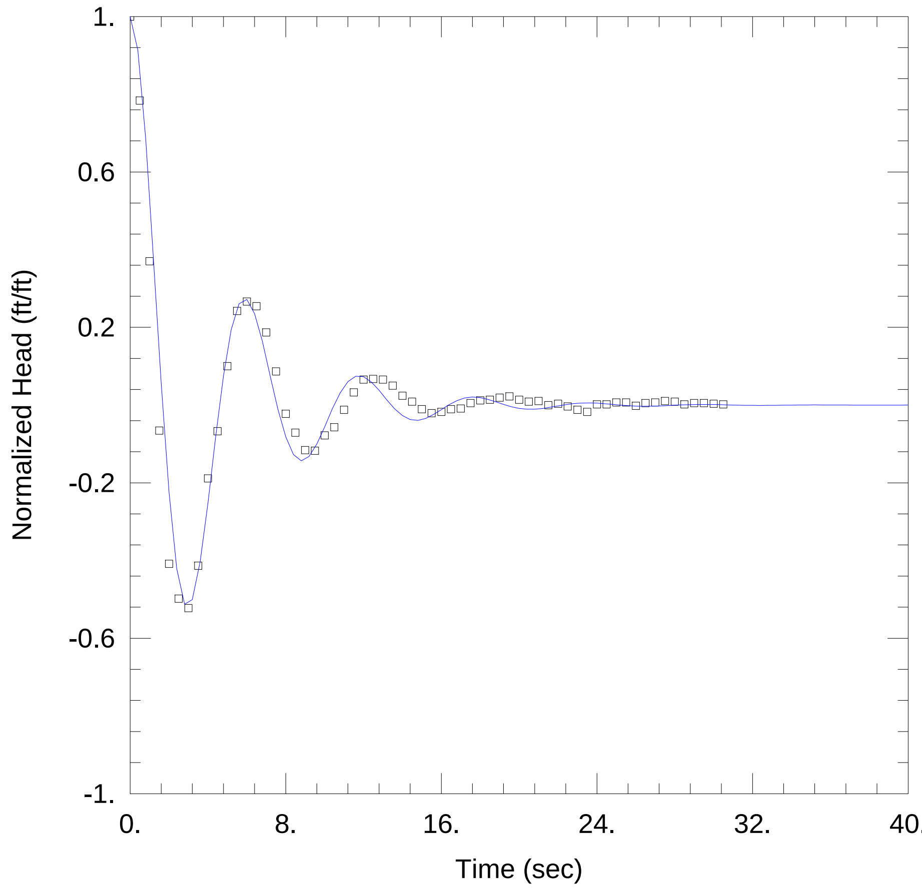
WELL DATA (RI-99-1)

Initial Displacement: 0.548 ft
Total Well Penetration Depth: 24. ft
Casing Radius: 0.042 ft
Static Water Column Height: 0. ft
Screen Length: 5. ft
Well Radius: 0.208 ft

SOLUTION

Aquifer Model: Confined
Solution Method: McElwee-Zenner

K = 0.04918 cm/sec
A = 0.
ß = 24.49 ft
v(0) = 0. cm/sec



10 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\99-1\Slug_RI_99-1_10b(-1)confined.aqt
Date: 02/12/14
Time: 16:10:06

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: RI MW 99-1
Test Date: 08/06/2013

AQUIFER DATA

Saturated Thickness: 40. ft
Anisotropy Ratio (Kz/Kr): 1.

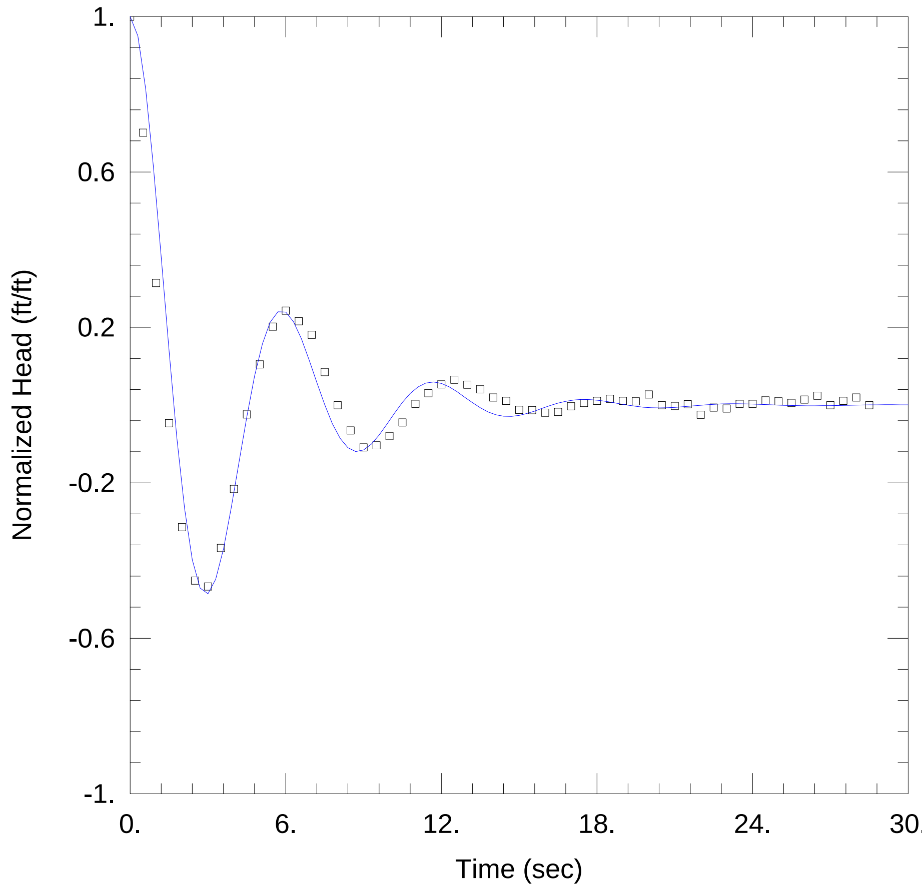
WELL DATA (RI-99-1)

Initial Displacement: 0.578 ft
Static Water Column Height: 0. ft
Total Well Penetration Depth: 24. ft
Screen Length: 5. ft
Casing Radius: 0.042 ft
Well Radius: 0.208 ft

SOLUTION

Aquifer Model: Confined
Solution Method: McElwee-Zenner

K = 0.04641 cm/sec
ß = 27.05 ft
A = 0.
v(0) = 0. cm/sec



15 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\99-1\Slug_RI_99-1_15a(-1)confined.aqt
Date: 02/12/14 Time: 16:11:50

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: RI MW 99-1
Test Date: 08/06/2013

AQUIFER DATA

Saturated Thickness: 40. ft
Anisotropy Ratio (Kz/Kr): 1.

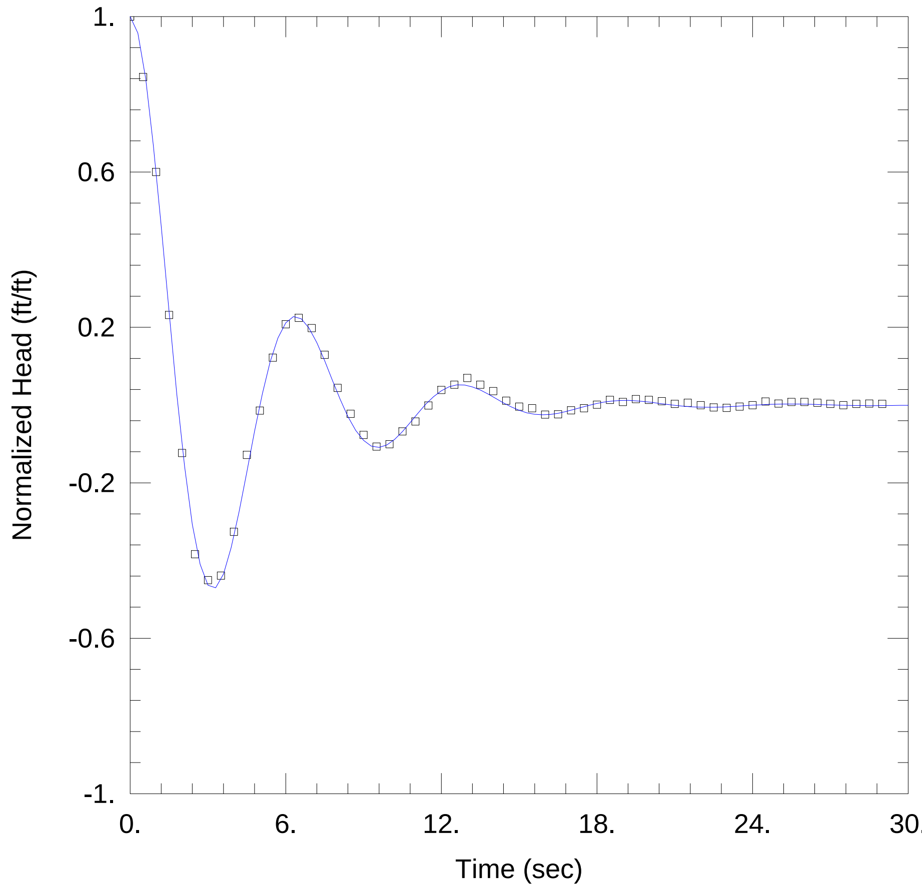
WELL DATA (RI-99-1)

Initial Displacement: 0.917 ft
Total Well Penetration Depth: 24. ft
Casing Radius: 0.042 ft
Static Water Column Height: 0. ft
Screen Length: 5. ft
Well Radius: 0.208 ft

SOLUTION

Aquifer Model: Confined
Solution Method: McElwee-Zenner

K = 0.04319 cm/sec
A = 0.
ß = 26.41 ft
v(0) = 0. cm/sec



15 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\99-1\Slug_RI_99-1_15b(-1)confined.aqt
Date: 02/12/14 Time: 16:13:16

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: RI MW 99-1
Test Date: 08/06/2013

AQUIFER DATA

Saturated Thickness: 40. ft Anisotropy Ratio (Kz/Kr): 1.

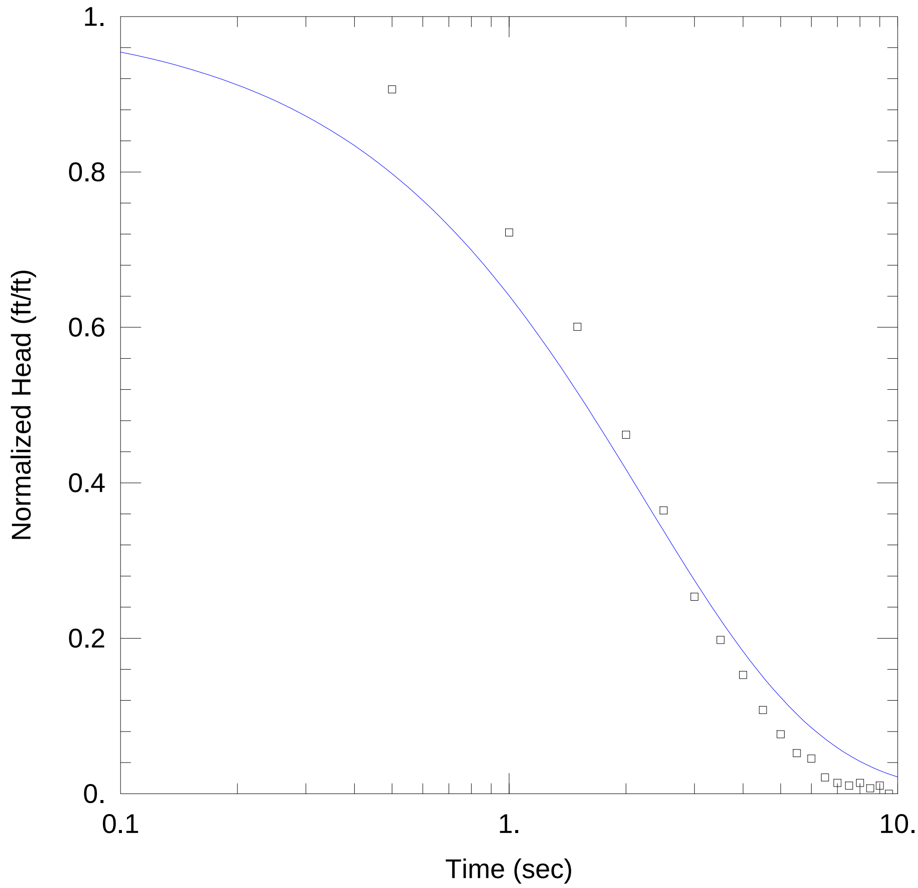
WELL DATA (RI-99-1)

Initial Displacement: 0.975 ft
Total Well Penetration Depth: 24. ft
Casing Radius: 0.042 ft
Static Water Column Height: 0. ft
Screen Length: 5. ft
Well Radius: 0.208 ft

SOLUTION

Aquifer Model: Confined
Solution Method: McElwee-Zenner

K = 0.03807 cm/sec
A = 0.
ß = 31.27 ft
v(0) = 0. cm/sec



5 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\99-5\Slug_RI_99-5_5a(-1)confined.aqt
Date: 02/13/14 Time: 08:56:56

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: MW 99-5
Test Date: 07/31/2013

AQUIFER DATA

Saturated Thickness: 34. ft

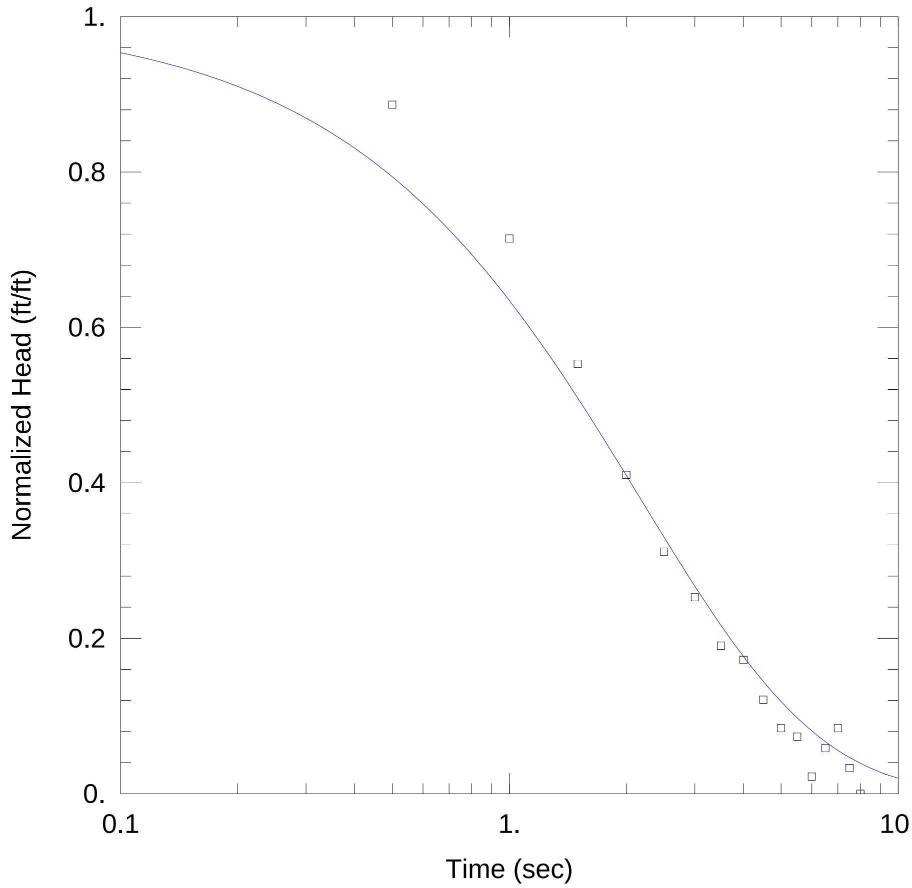
WELL DATA (RI-99-5)

Initial Displacement: 0.288 ft
Total Well Penetration Depth: 18. ft
Casing Radius: 0.042 ft
Static Water Column Height: 0. ft
Screen Length: 5. ft
Well Radius: 0.208 ft

SOLUTION

Aquifer Model: Confined
Solution Method: KGS Model

Kr = 0.009041 cm/sec
Kz/Kr = 1.
Ss = 2.857E-12 ft^{-1}



5 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\99-5\Slug_RI_99-5_5b(-1)confined.aqt
Date: 02/13/14 Time: 08:55:39

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: MW 99-5
Test Date: 07/31/2013

AQUIFER DATA

Saturated Thickness: 34. ft

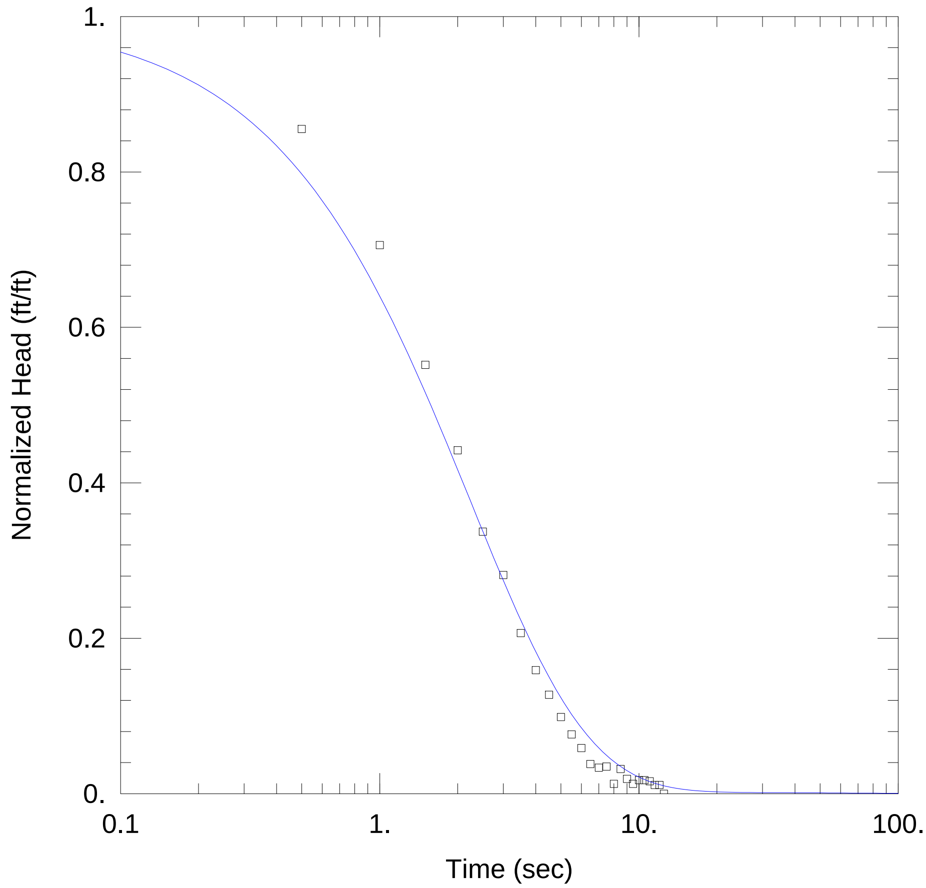
WELL DATA (RI-99-5)

Initial Displacement: 0.273 ft
Total Well Penetration Depth: 18. ft
Casing Radius: 0.042 ft
Static Water Column Height: 0. ft
Screen Length: 5. ft
Well Radius: 0.208 ft
Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined
Solution Method: KGS Model

Kr = 0.01424 cm/sec
Kz/Kr = 1.
Ss = 2.857E-12 ft^{-1}



10 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\99-5\Slug_RI_99-5_10a(-1)confined.aqt
Date: 02/13/14 Time: 17:45:04

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: MW 99-5
Test Date: 07/31/2013

AQUIFER DATA

Saturated Thickness: 34. ft

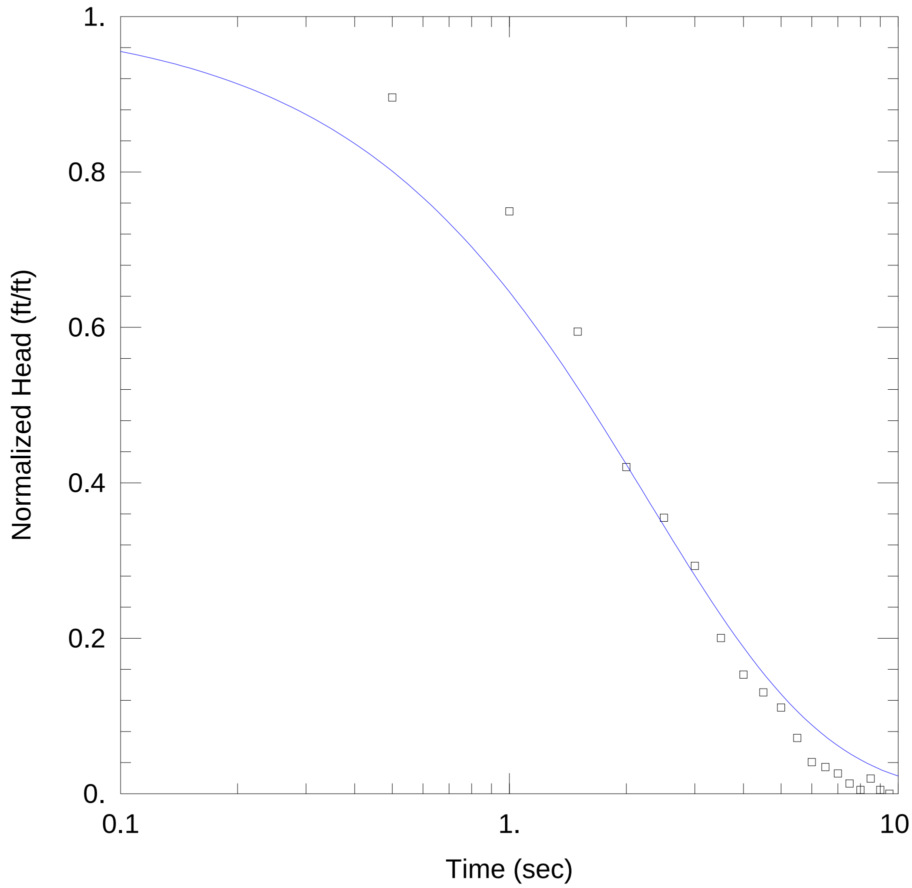
WELL DATA (RI-99-5)

Initial Displacement: 0.629 ft
Total Well Penetration Depth: 18. ft
Casing Radius: 0.042 ft
Static Water Column Height: 0. ft
Screen Length: 5. ft
Well Radius: 0.208 ft
Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined
Solution Method: KGS Model

Kr = 0.01196 cm/sec
Kz/Kr = 1.
Ss = 4.37E-12 ft^{-1}



10 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\99-5\Slug_RI_99-5_10b(-1)confined.aqt
Date: 02/13/14 Time: 17:48:07

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: MW 99-5
Test Date: 07/31/2013

AQUIFER DATA

Saturated Thickness: 34. ft

WELL DATA (RI-99-5)

Initial Displacement: 0.614 ft
Total Well Penetration Depth: 18. ft
Casing Radius: 0.042 ft

Static Water Column Height: 0. ft
Screen Length: 5. ft
Well Radius: 0.208 ft
Gravel Pack Porosity: 0.

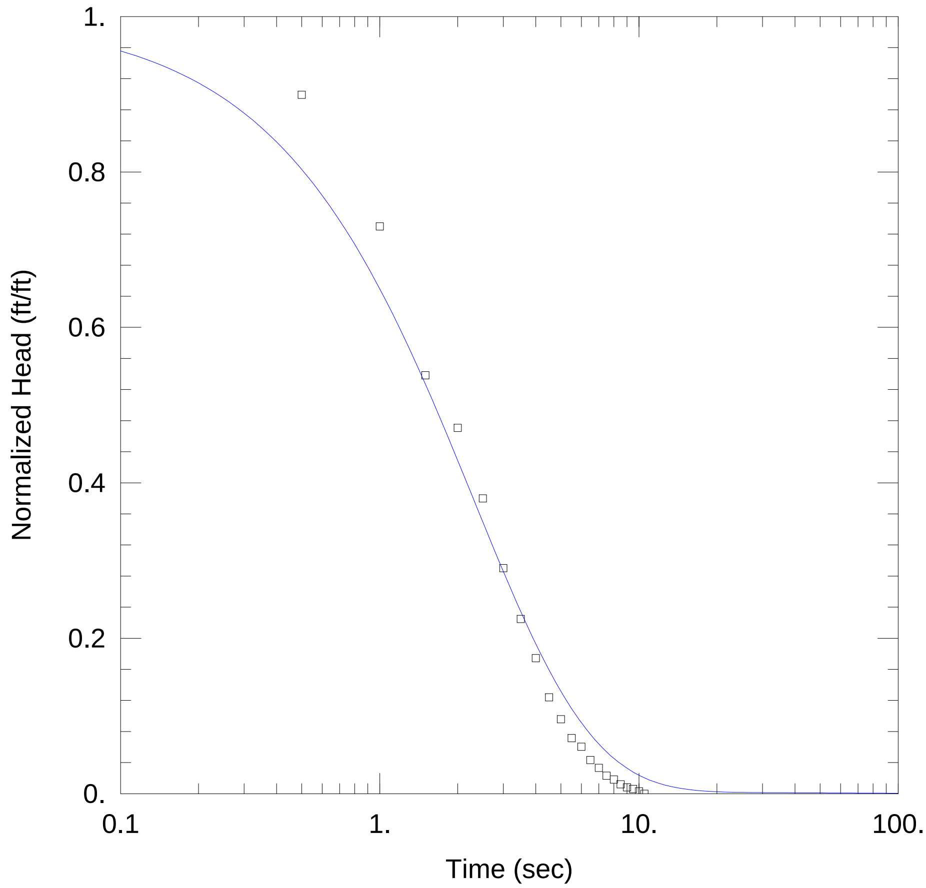
SOLUTION

Aquifer Model: Confined

Solution Method: KGS Model

Kr = 0.01202 cm/sec
Kz/Kr = 1.

Ss = 4.37E-12 ft^{-1}



15 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\99-5\Slug_RI_99-5_15a(-1)confined.aqt
Date: 02/13/14 Time: 17:50:11

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: MW 99-5
Test Date: 07/31/2013

AQUIFER DATA

Saturated Thickness: 34. ft

WELL DATA (RI-99-5)

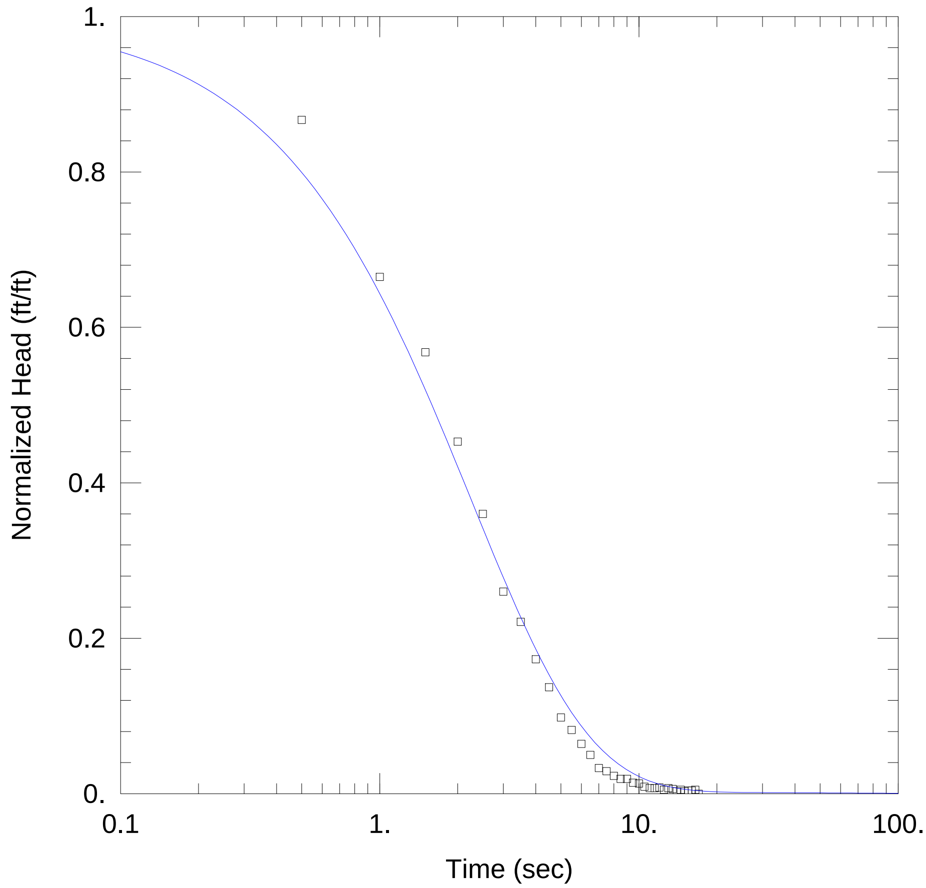
Initial Displacement: 0.992 ft
Total Well Penetration Depth: 18. ft
Casing Radius: 0.042 ft

Static Water Column Height: 0. ft
Screen Length: 5. ft
Well Radius: 0.208 ft
Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined
Solution Method: KGS Model

Kr = 0.01099 cm/sec
Kz/Kr = 1.
Ss = 4.37E-12 ft^{-1}



15 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\99-5\Slug_RI_99-5_15b(-1)confined.aqt
Date: 02/13/14 Time: 17:52:08

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: MW 99-5
Test Date: 07/31/2013

AQUIFER DATA

Saturated Thickness: 34. ft

WELL DATA (RI-99-5)

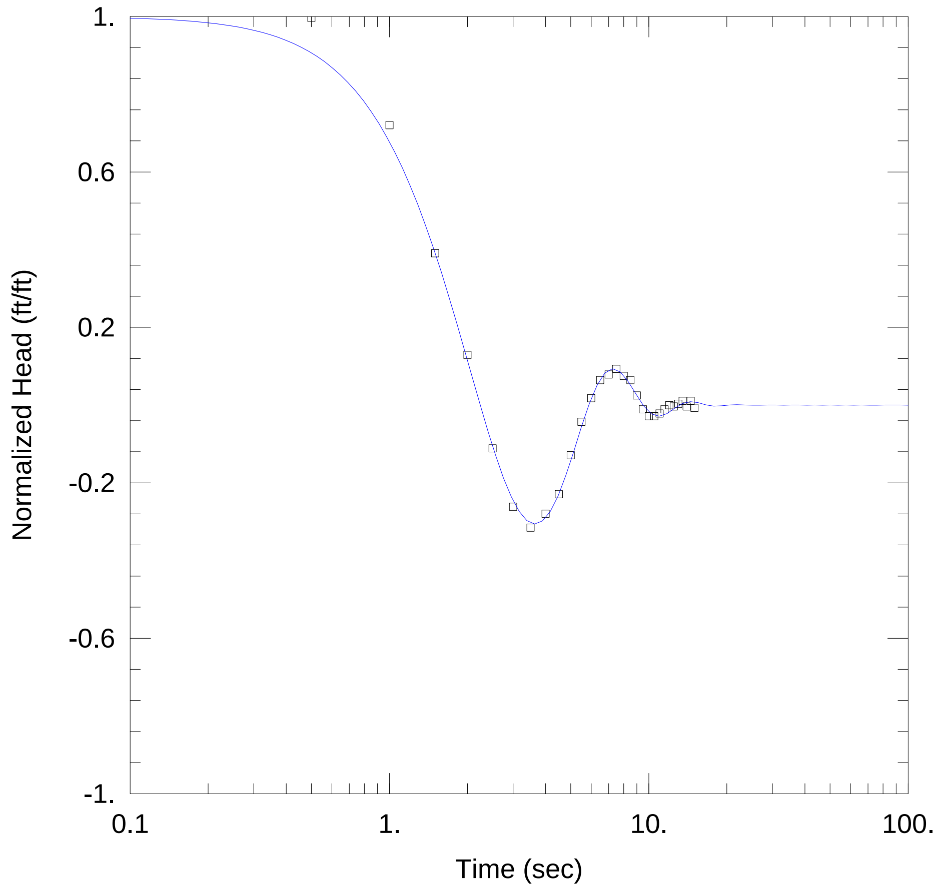
Initial Displacement: 1. ft
Total Well Penetration Depth: 18. ft
Casing Radius: 0.042 ft

Static Water Column Height: 0. ft
Screen Length: 5. ft
Well Radius: 0.208 ft
Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined
Solution Method: KGS Model

Kr = 0.01115 cm/sec
Kz/Kr = 1.
Ss = 4.37E-12 ft^{-1}



5 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\99-7\Slug_RI_99-7_5a(-1)confined.aqt
Date: 02/13/14 Time: 09:08:51

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: MW 99-7
Test Date: 08/06/2013

AQUIFER DATA

Saturated Thickness: 34. ft
Anisotropy Ratio (Kz/Kr): 1.

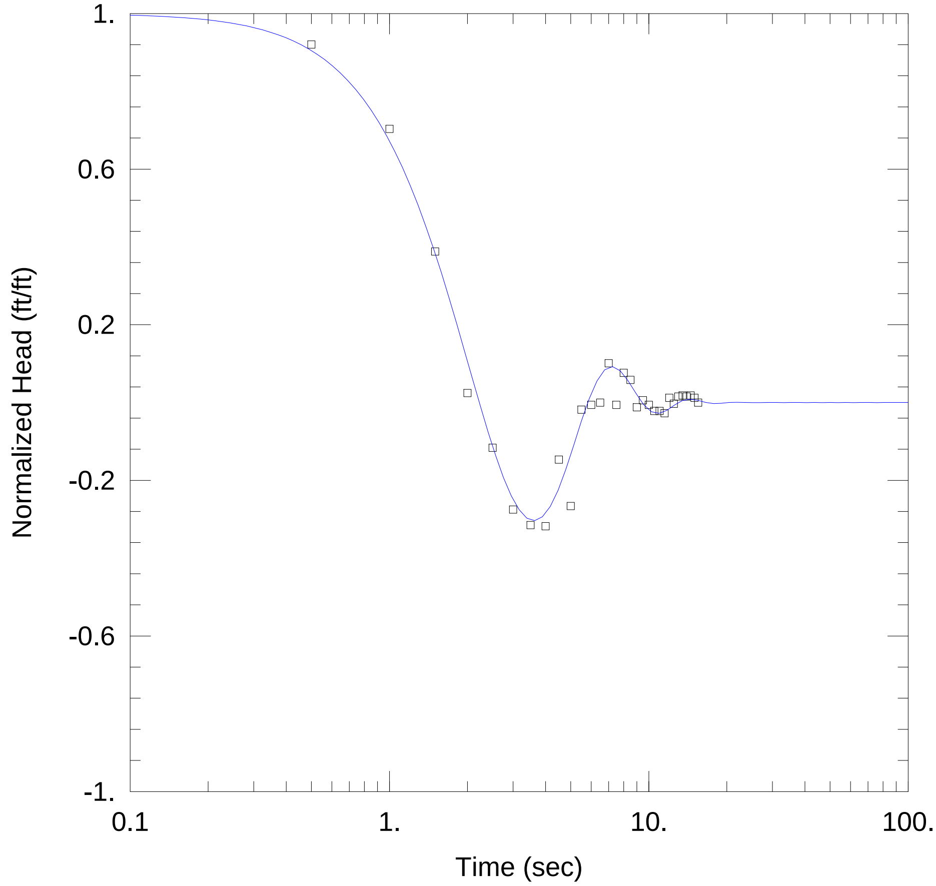
WELL DATA (RI-99-7)

Initial Displacement: 0.279 ft
Total Well Penetration Depth: 17.99 ft
Casing Radius: 0.042 ft
Static Water Column Height: 0. ft
Screen Length: 5. ft
Well Radius: 0.208 ft
Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined
Solution Method: McElwee-Zenner

K = 0.02242 cm/sec
A = 0.
ß = 37.74 ft
v(0) = 0. cm/sec



5 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\99-7\Slug_RI_99-7_5b(-1)confined.aqt
Date: 02/13/14 Time: 10:27:05

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: MW 99-7
Test Date: 08/06/2013

AQUIFER DATA

Saturated Thickness: 34. ft Anisotropy Ratio (Kz/Kr): 1.

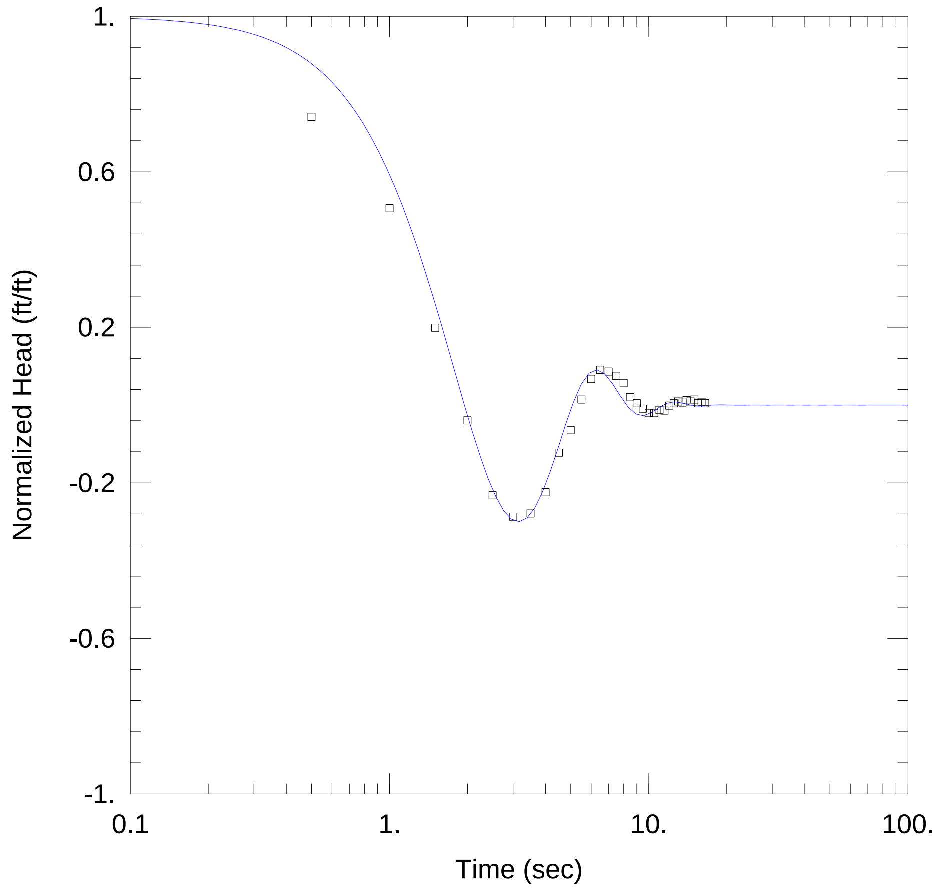
WELL DATA (RI-99-7)

Initial Displacement: 0.327 ft Static Water Column Height: 0. ft
Total Well Penetration Depth: 17.99 ft Screen Length: 5. ft
Casing Radius: 0.042 ft Well Radius: 0.208 ft

SOLUTION

Aquifer Model: Confined Solution Method: McElwee-Zenner

K = 0.02255 cm/sec ß = 36.96 ft
A = 0. v(0) = 0. cm/sec



10 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\99-7\Slug_RI_99-7_10a(-1)confined.aqt
Date: 02/13/14 Time: 10:30:03

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: MW 99-7
Test Date: 08/06/2013

AQUIFER DATA

Saturated Thickness: 34. ft Anisotropy Ratio (Kz/Kr): 1.

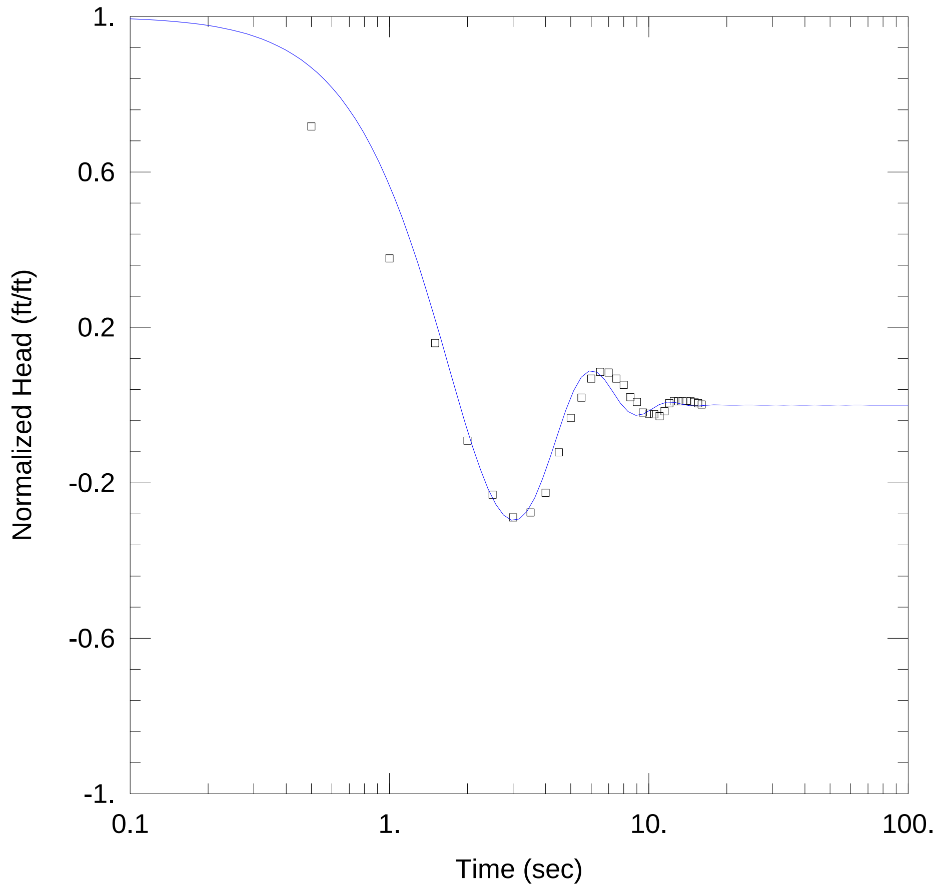
WELL DATA (RI-99-7)

Initial Displacement: 0.638 ft
Total Well Penetration Depth: 17.99 ft
Casing Radius: 0.042 ft
Static Water Column Height: 0. ft
Screen Length: 5. ft
Well Radius: 0.208 ft

SOLUTION

Aquifer Model: Confined
Solution Method: McElwee-Zenner

K = 0.02576 cm/sec
A = 0.
ß = 28.01 ft
v(0) = 0. cm/sec



10 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\99-7\Slug_RI_99-7_10b(-1)confined.aqt
Date: 02/13/14 Time: 10:32:03

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: MW 99-7
Test Date: 08/06/2013

AQUIFER DATA

Saturated Thickness: 34. ft
Anisotropy Ratio (Kz/Kr): 1.

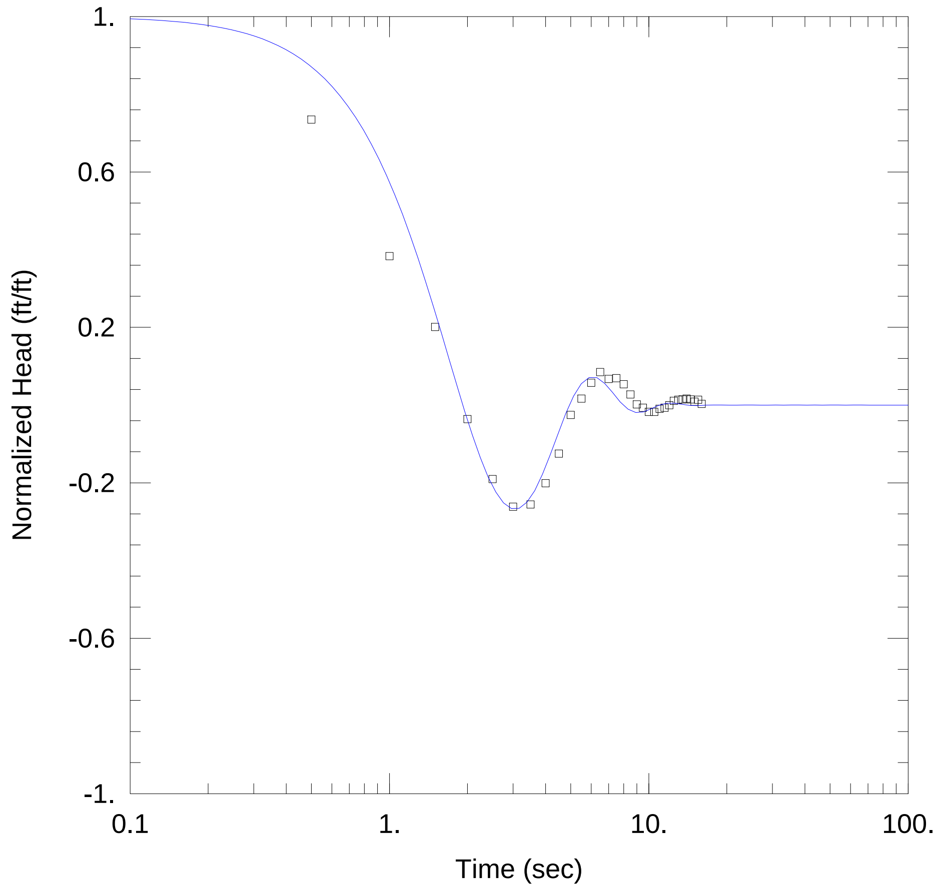
WELL DATA (RI-99-7)

Initial Displacement: 0.633 ft
Total Well Penetration Depth: 17.99 ft
Casing Radius: 0.042 ft
Static Water Column Height: 0. ft
Screen Length: 5. ft
Well Radius: 0.208 ft

SOLUTION

Aquifer Model: Confined
Solution Method: McElwee-Zenner

K = 0.02669 cm/sec
A = 0.
ß = 25.68 ft
v(0) = 0. cm/sec



15 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\99-7\Slug_RI_99-7_15a(-1)confined.aqt
Date: 02/13/14 Time: 10:33:43

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: MW 99-7
Test Date: 08/06/2013

AQUIFER DATA

Saturated Thickness: 34. ft
Anisotropy Ratio (Kz/Kr): 1.

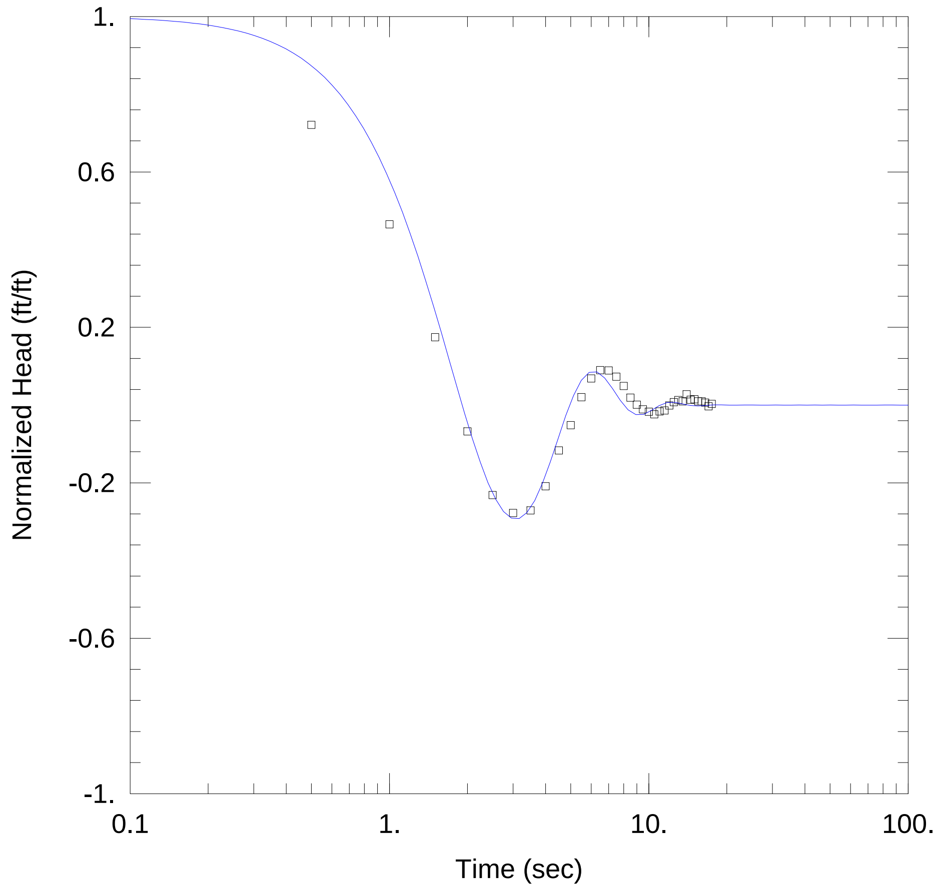
WELL DATA (RI-99-7)

Initial Displacement: 1.025 ft
Total Well Penetration Depth: 17.99 ft
Casing Radius: 0.042 ft
Static Water Column Height: 0. ft
Screen Length: 5. ft
Well Radius: 0.208 ft

SOLUTION

Aquifer Model: Confined
Solution Method: McElwee-Zenner

K = 0.025 cm/sec
A = 0.
ß = 25.54 ft
v(0) = 0. cm/sec



15 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\99-7\Slug_RI_99-7_15b(-1)confined.aqt
Date: 02/13/14
Time: 10:35:46

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: MW 99-7
Test Date: 08/06/2013

AQUIFER DATA

Saturated Thickness: 34. ft
Anisotropy Ratio (Kz/Kr): 1.

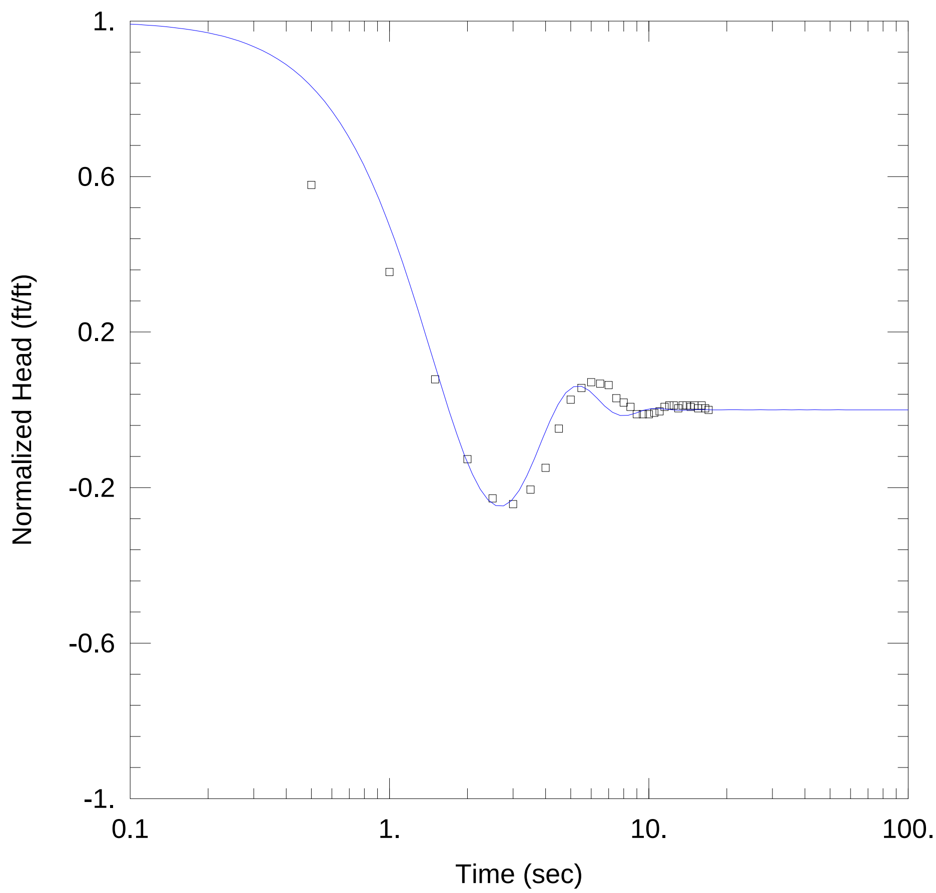
WELL DATA (RI-99-7)

Initial Displacement: 0.933 ft
Static Water Column Height: 0. ft
Total Well Penetration Depth: 17.99 ft
Screen Length: 5. ft
Casing Radius: 0.042 ft
Well Radius: 0.208 ft

SOLUTION

Aquifer Model: Confined
Solution Method: McElwee-Zenner

K = 0.02612 cm/sec
ß = 26.49 ft
A = 0.
v(0) = 0. cm/sec



5 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\99-11\Slug_RI_99-11_5a(-1)confined.aqt
Date: 02/13/14 Time: 10:40:19

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: MW 99-11
Test Date: 07/31/2013

AQUIFER DATA

Saturated Thickness: 36. ft Anisotropy Ratio (Kz/Kr): 1.

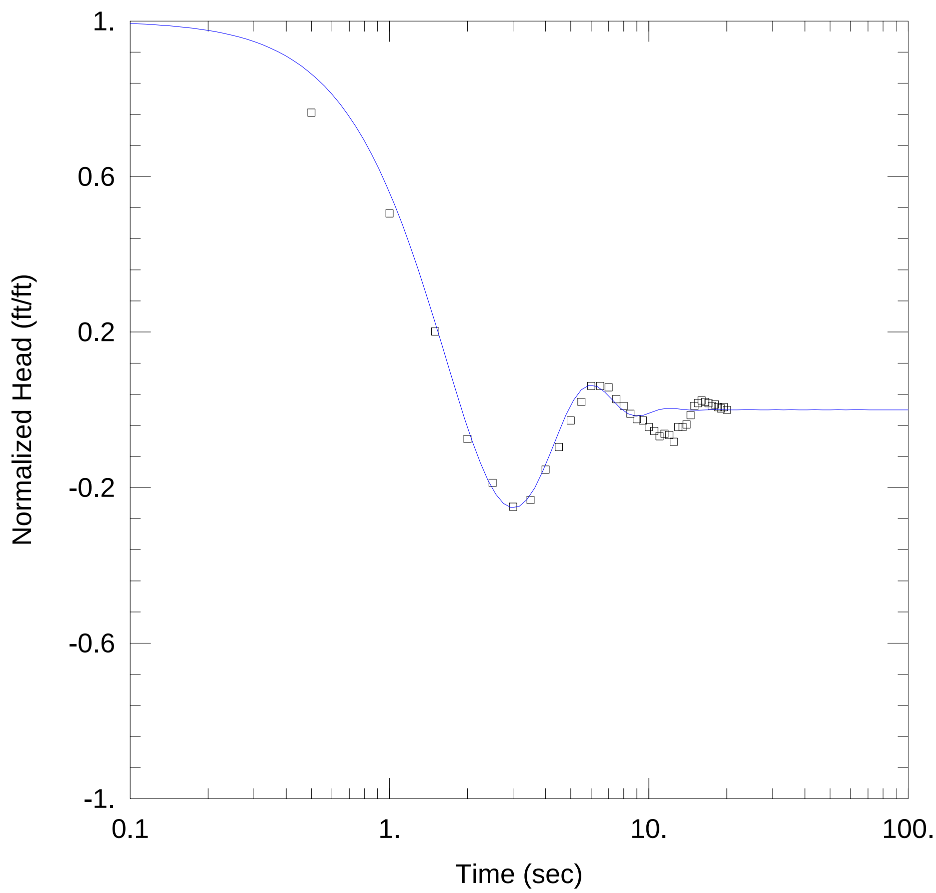
WELL DATA (RI-99-11)

Initial Displacement: 0.268 ft Static Water Column Height: 0. ft
Total Well Penetration Depth: 8. ft Screen Length: 5. ft
Casing Radius: 0.042 ft Well Radius: 0.208 ft
Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined Solution Method: McElwee-Zenner

K = 0.02725 cm/sec ß = 19.38 ft
A = 0. v(0) = 0. cm/sec



5 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\99-11\Slug_RI_99-11_5b(-1)confined.aqt
Date: 02/13/14
Time: 10:42:50

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: MW 99-11
Test Date: 07/31/2013

AQUIFER DATA

Saturated Thickness: 36. ft
Anisotropy Ratio (Kz/Kr): 1.

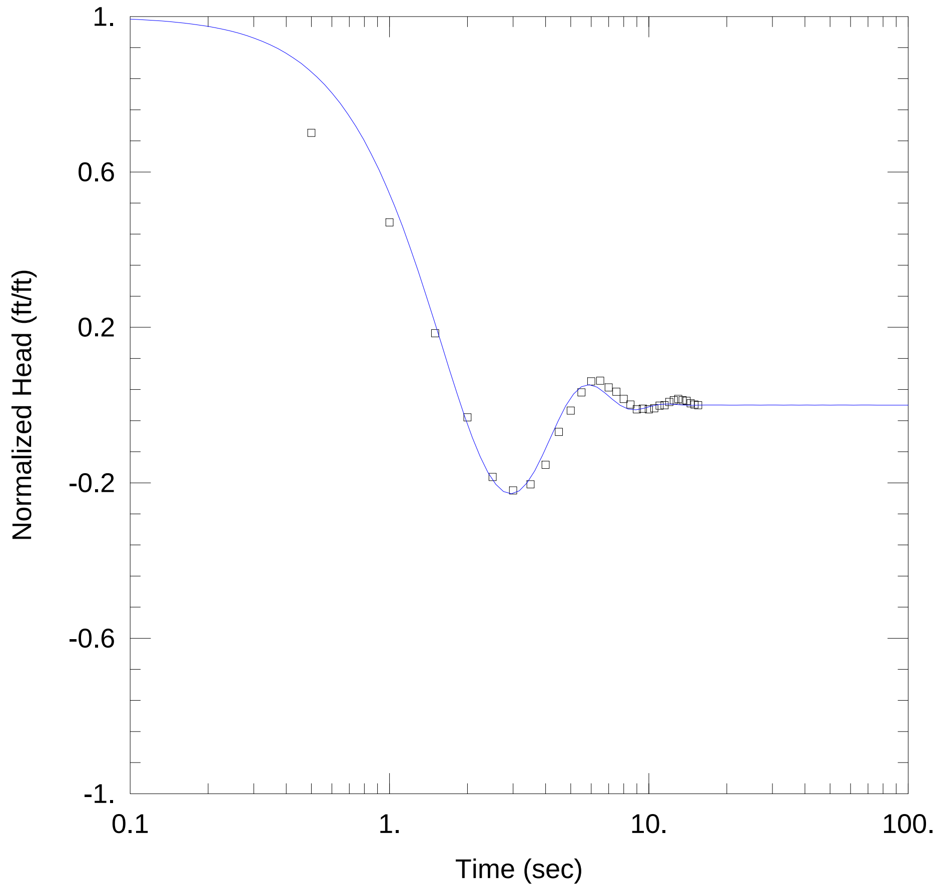
WELL DATA (RI-99-11)

Initial Displacement: 0.293 ft
Total Well Penetration Depth: 8. ft
Casing Radius: 0.042 ft
Static Water Column Height: 0. ft
Screen Length: 5. ft
Well Radius: 0.208 ft
Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined
Solution Method: McElwee-Zenner

K = 0.02439 cm/sec
A = 0.
ß = 24.65 ft
v(0) = 0. cm/sec



10 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\99-11\Slug_RI_99-11_10a(-1)confined.aqt
Date: 02/13/14 Time: 10:44:42

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: MW 99-11
Test Date: 07/31/2013

AQUIFER DATA

Saturated Thickness: 36. ft
Anisotropy Ratio (Kz/Kr): 1.

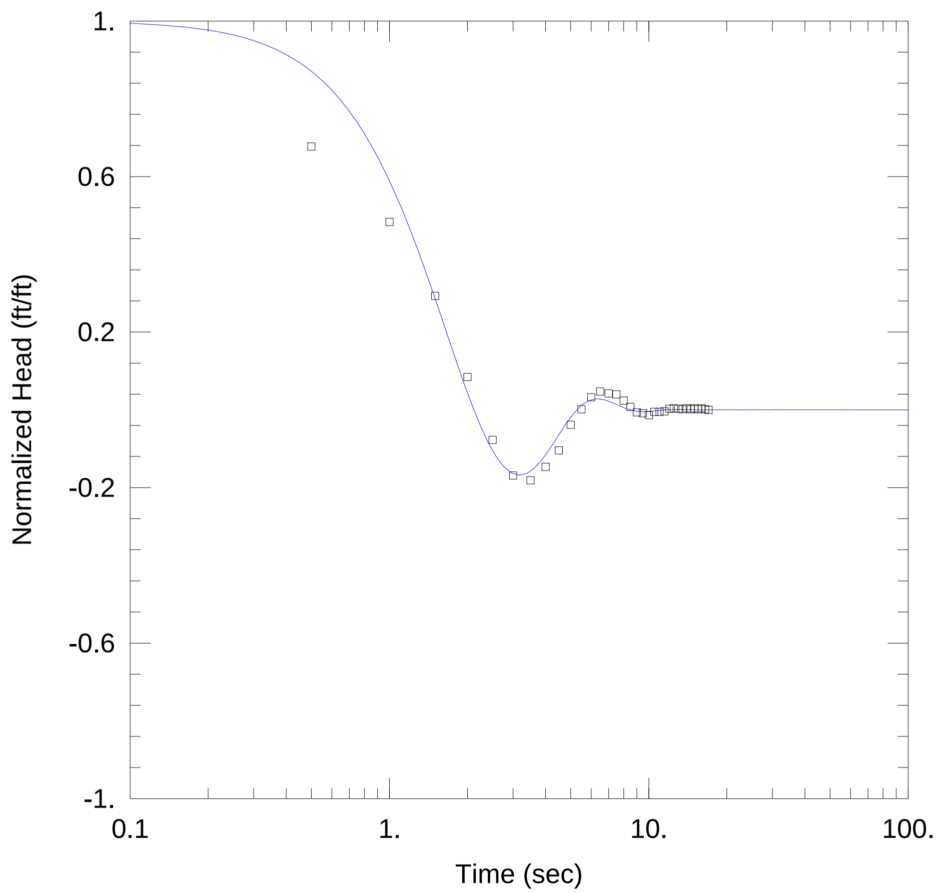
WELL DATA (RI-99-11)

Initial Displacement: 0.638 ft
Total Well Penetration Depth: 8. ft
Casing Radius: 0.042 ft
Static Water Column Height: 0. ft
Screen Length: 5. ft
Well Radius: 0.208 ft
Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined
Solution Method: McElwee-Zenner

K = 0.02392 cm/sec
A = 0.
ß = 22.89 ft
v(0) = 0. cm/sec



10 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\99-11\Slug_RI_99-11_10b(-1)confined.aqt
Date: 02/13/14 Time: 10:47:31

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: MW 99-11
Test Date: 07/31/2013

AQUIFER DATA

Saturated Thickness: 36. ft Anisotropy Ratio (Kz/Kr): 1.

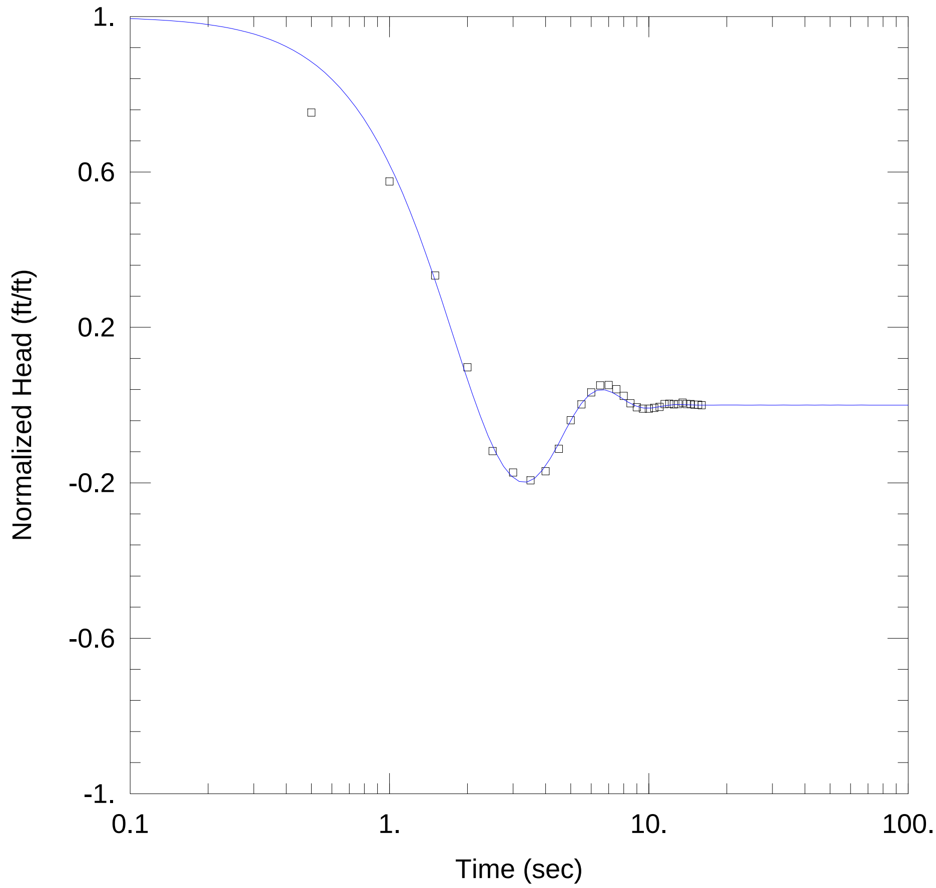
WELL DATA (RI-99-11)

Initial Displacement: 0.805 ft
Total Well Penetration Depth: 8. ft
Casing Radius: 0.042 ft
Static Water Column Height: 0. ft
Screen Length: 5. ft
Well Radius: 0.208 ft
Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined Solution Method: McElwee-Zenner

K = 0.01983 cm/sec
A = 0.
ß = 24.7 ft
v(0) = 0. cm/sec



15 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\99-11\Slug_RI_99-11_15a(-1)confined.aqt
Date: 02/13/14 Time: 10:50:37

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: MW 99-11
Test Date: 07/31/2013

AQUIFER DATA

Saturated Thickness: 36. ft
Anisotropy Ratio (Kz/Kr): 1.

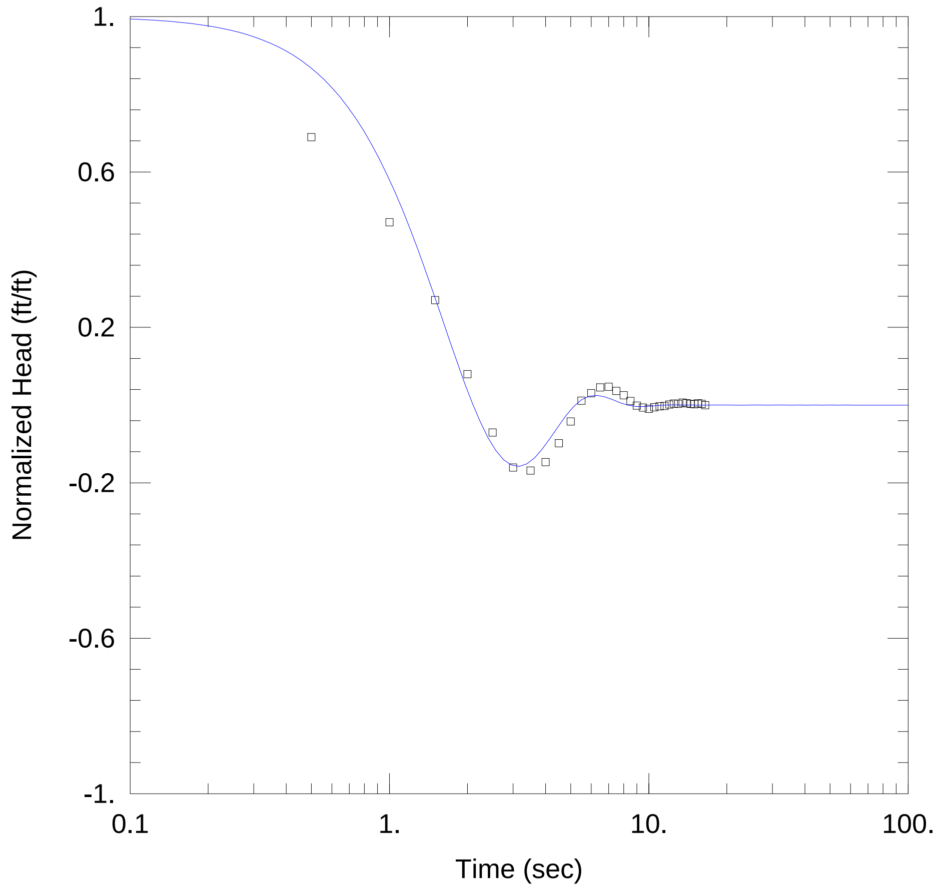
WELL DATA (RI-99-11)

Initial Displacement: 1.1 ft
Total Well Penetration Depth: 8. ft
Casing Radius: 0.042 ft
Static Water Column Height: 0. ft
Screen Length: 5. ft
Well Radius: 0.208 ft
Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined
Solution Method: McElwee-Zenner

K = 0.02015 cm/sec
A = 0.
ß = 27.96 ft
v(0) = 0. cm/sec



15 INCH FALLING HEAD

Data Set: G:\PROJECTS\Prospect_Island\Slug_Testing\99-11\Slug_RI_99-11_15b(-1)confined.aqt
Date: 02/13/14 Time: 10:53:35

PROJECT INFORMATION

Company: NCRO
Client: DES
Project: Prospect Island
Location: Solano County
Test Well: MW 99-11
Test Date: 07/31/2013

AQUIFER DATA

Saturated Thickness: 36. ft
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (RI-99-11)

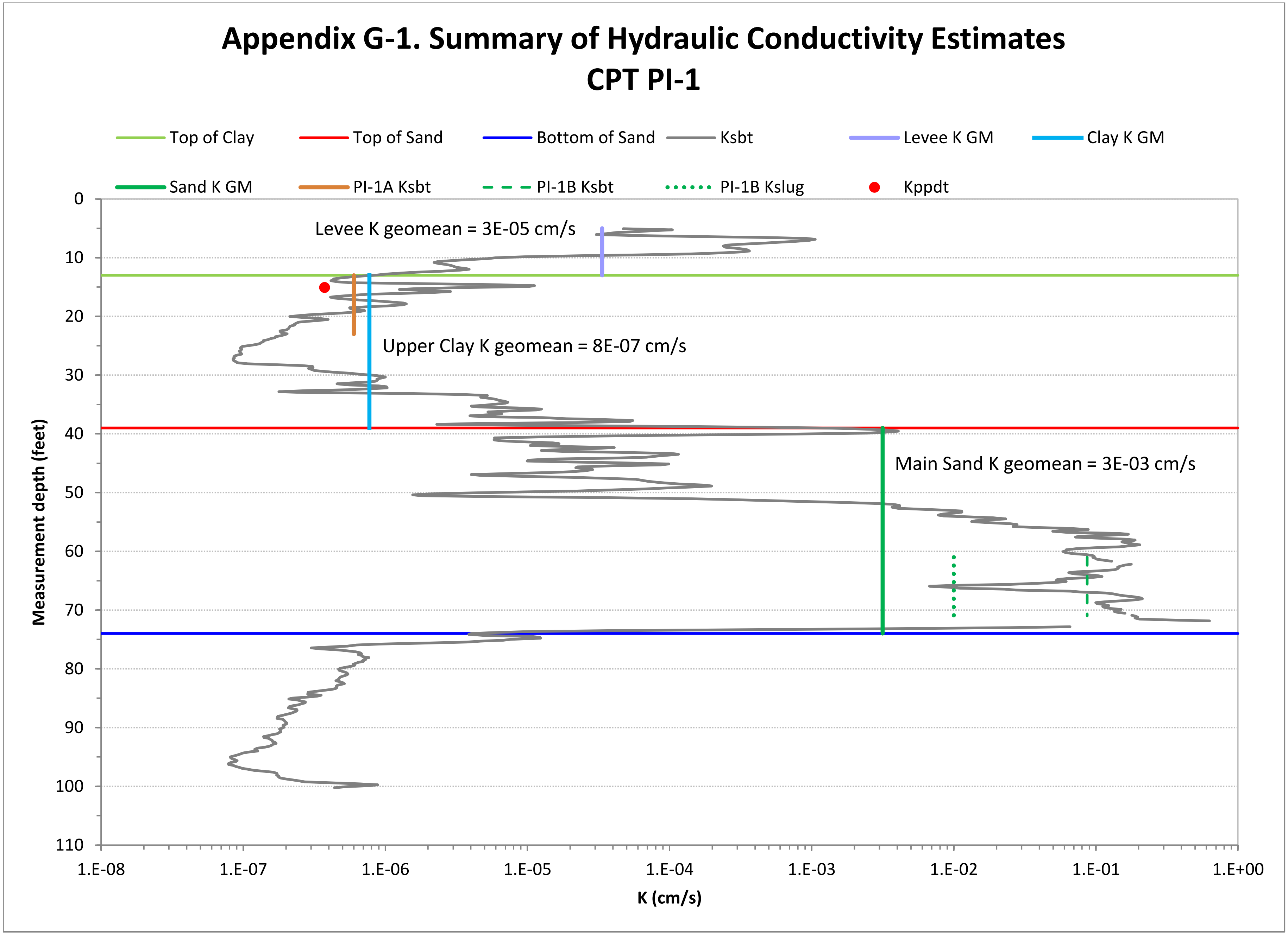
Initial Displacement: 1.233 ft
Total Well Penetration Depth: 8. ft
Casing Radius: 0.042 ft
Static Water Column Height: 0. ft
Screen Length: 5. ft
Well Radius: 0.208 ft
Gravel Pack Porosity: 0.

SOLUTION

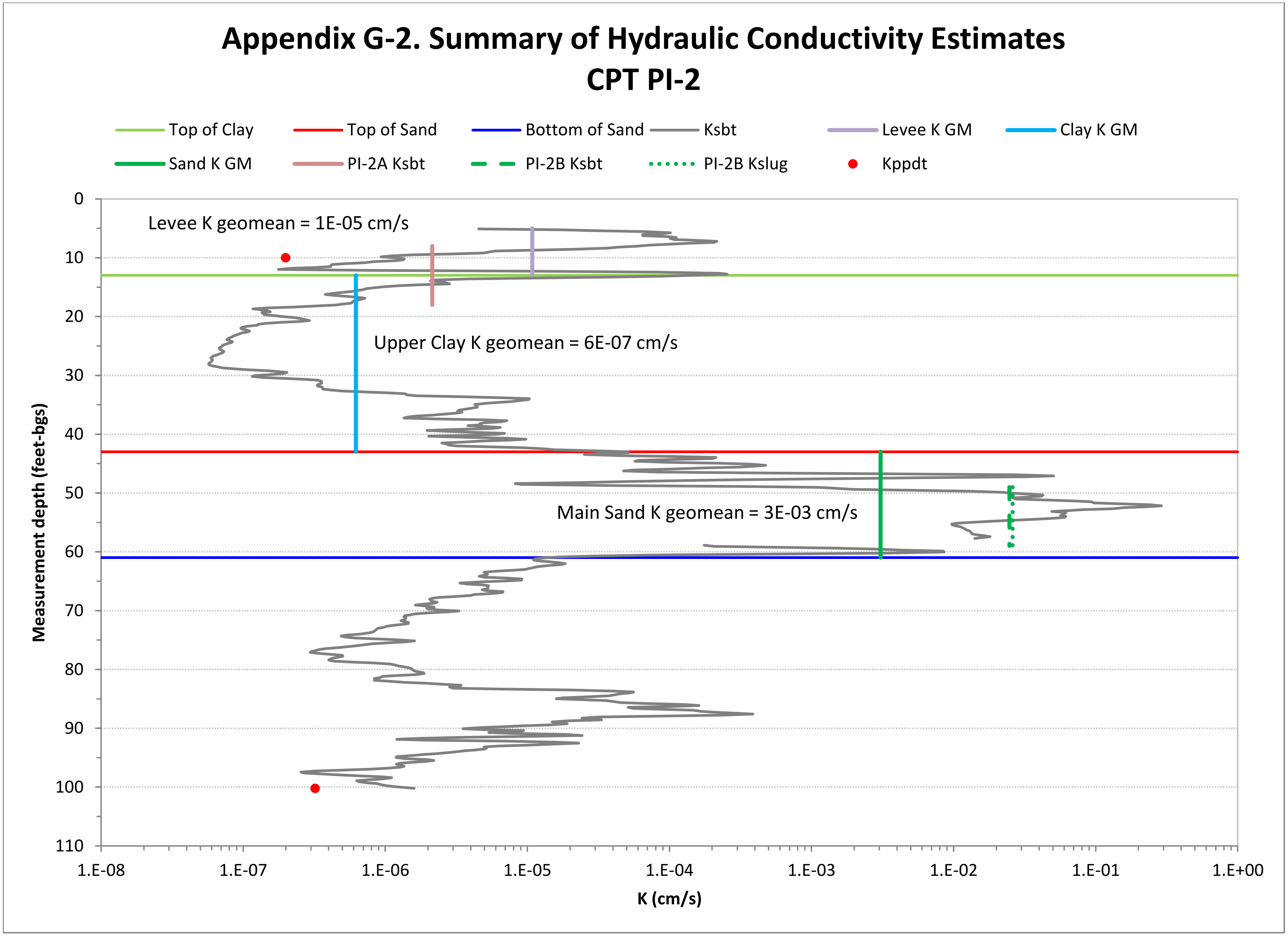
Aquifer Model: Confined
Solution Method: McElwee-Zenner

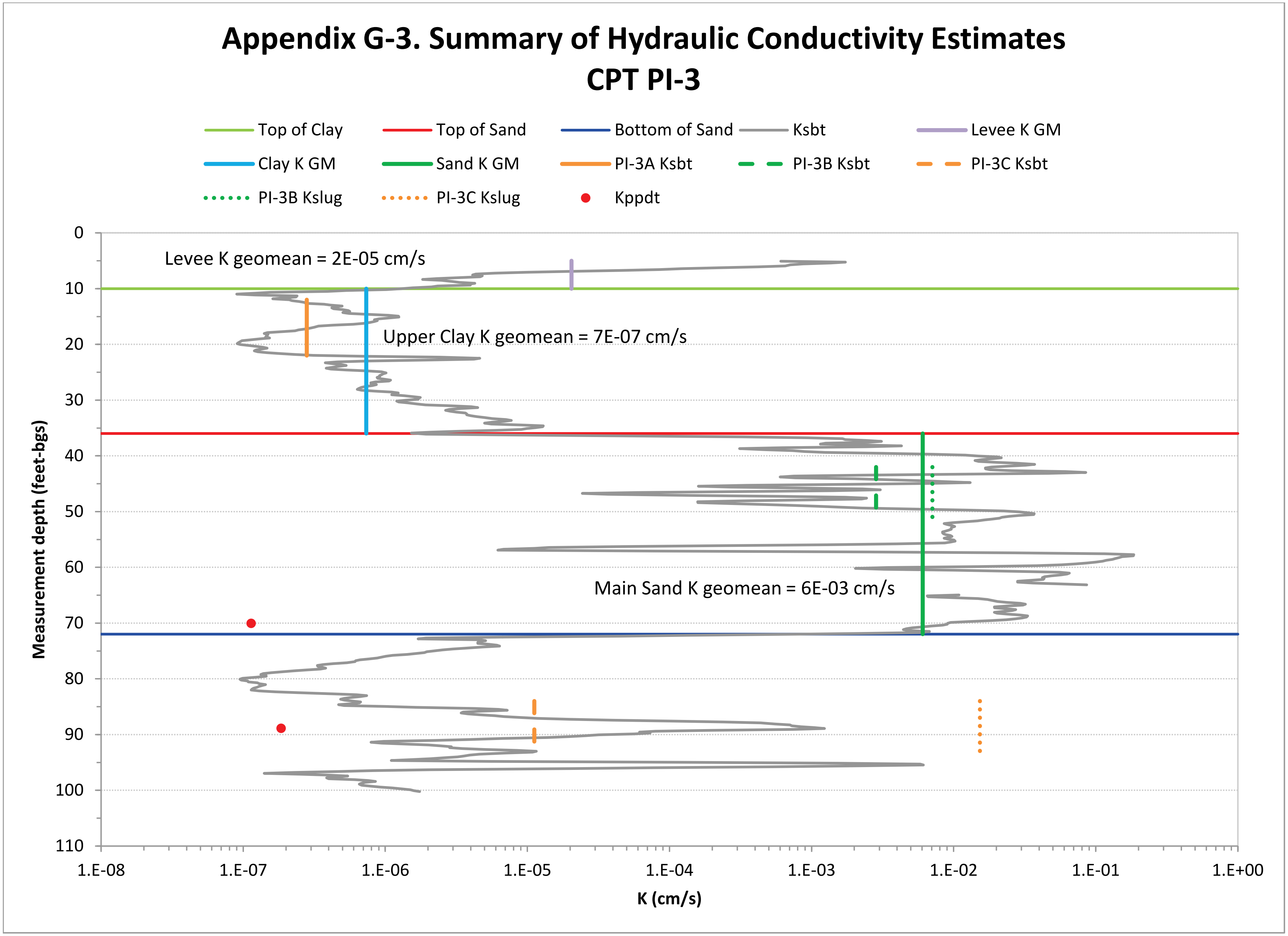
K = 0.01986 cm/sec
A = 0.
ß = 23.42 ft
v(0) = 0. cm/sec

Appendix G. Summary of K Estimates



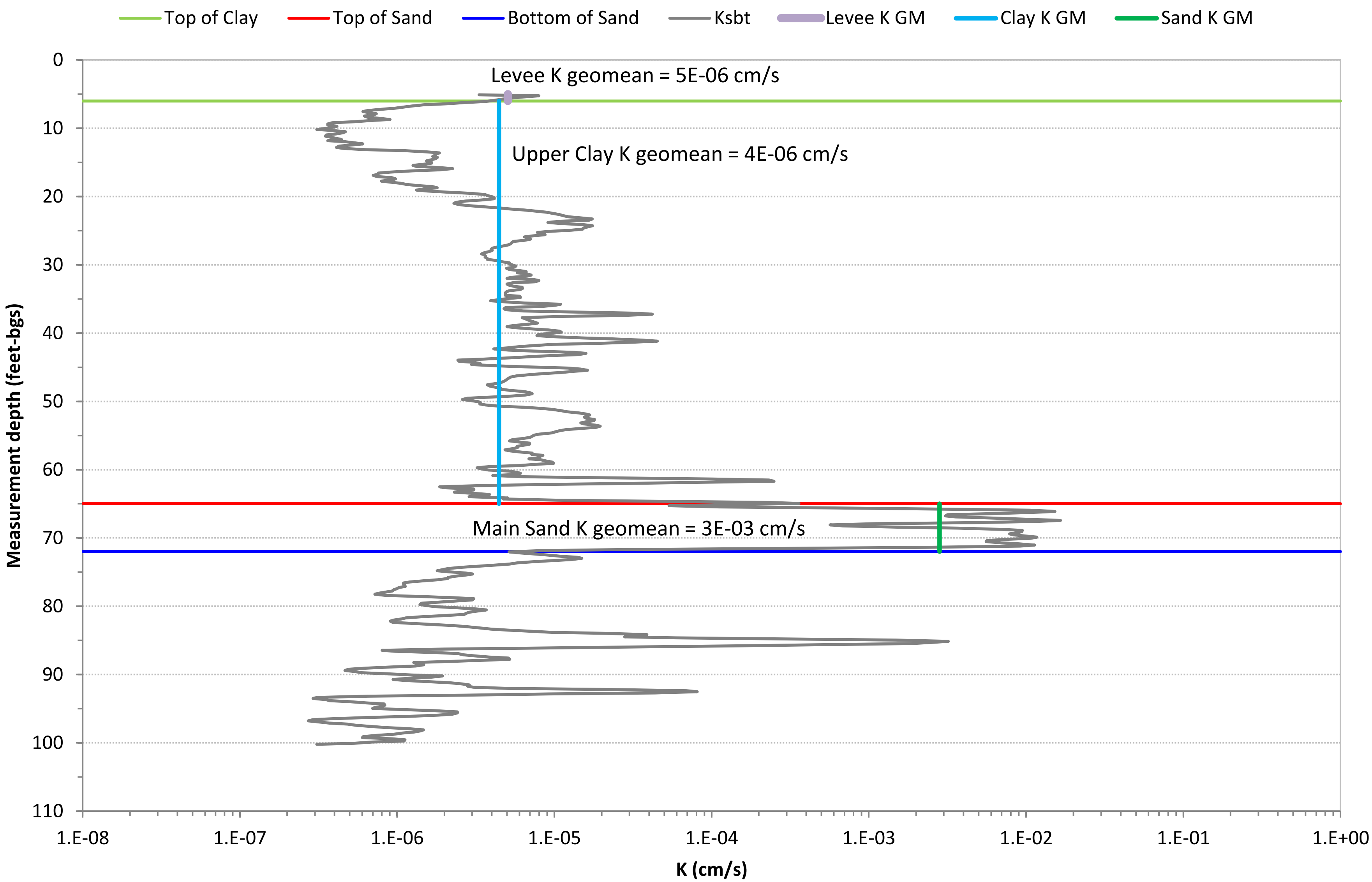
Appendix G-1. Summary of Hydraulic Conductivity Estimates
CPT PI-1
Top of Clay
Top of Sand
Bottom of Sand
Ksbt
Levee K GM
Clay K GM
Sand K GM
PI-1A Ksbt
PI-1B Ksbt
PI-1B Kslug
Kppdt
Levee K geomean = 3E-05 cm/s
Upper Clay K geomean = 8E-07 cm/s
Main Sand K geomean = 3E-03 cm/s
Measurement depth (feet)
K (cm/s)
0
10
20
30
40
50
60
70
80
90
100
110
1.E-08
1.E-07
1.E-06
1.E-05
1.E-04
1.E-03
1.E-02
1.E-01
1.E+00


Appendix G-2. Summary of Hydraulic Conductivity Estimates
CPT PI-2
Top of Clay
Top of Sand
Bottom of Sand
Ksbt
Levee K GM
Clay K GM
Sand K GM
PI-2A Ksbt
PI-2B Ksbt
PI-2B Kslug
Kppdt
Levee K geomean = 1E-05 cm/s
Upper Clay K geomean = 6E-07 cm/s
Main Sand K geomean = 3E-03 cm/s
Measurement depth (feet-bgs)
0
10
20
30
40
50
60
70
80
90
100
110
1.E-08
1.E-07
1.E-06
1.E-05
1.E-04
1.E-03
1.E-02
1.E-01
1.E+00
K (cm/s)

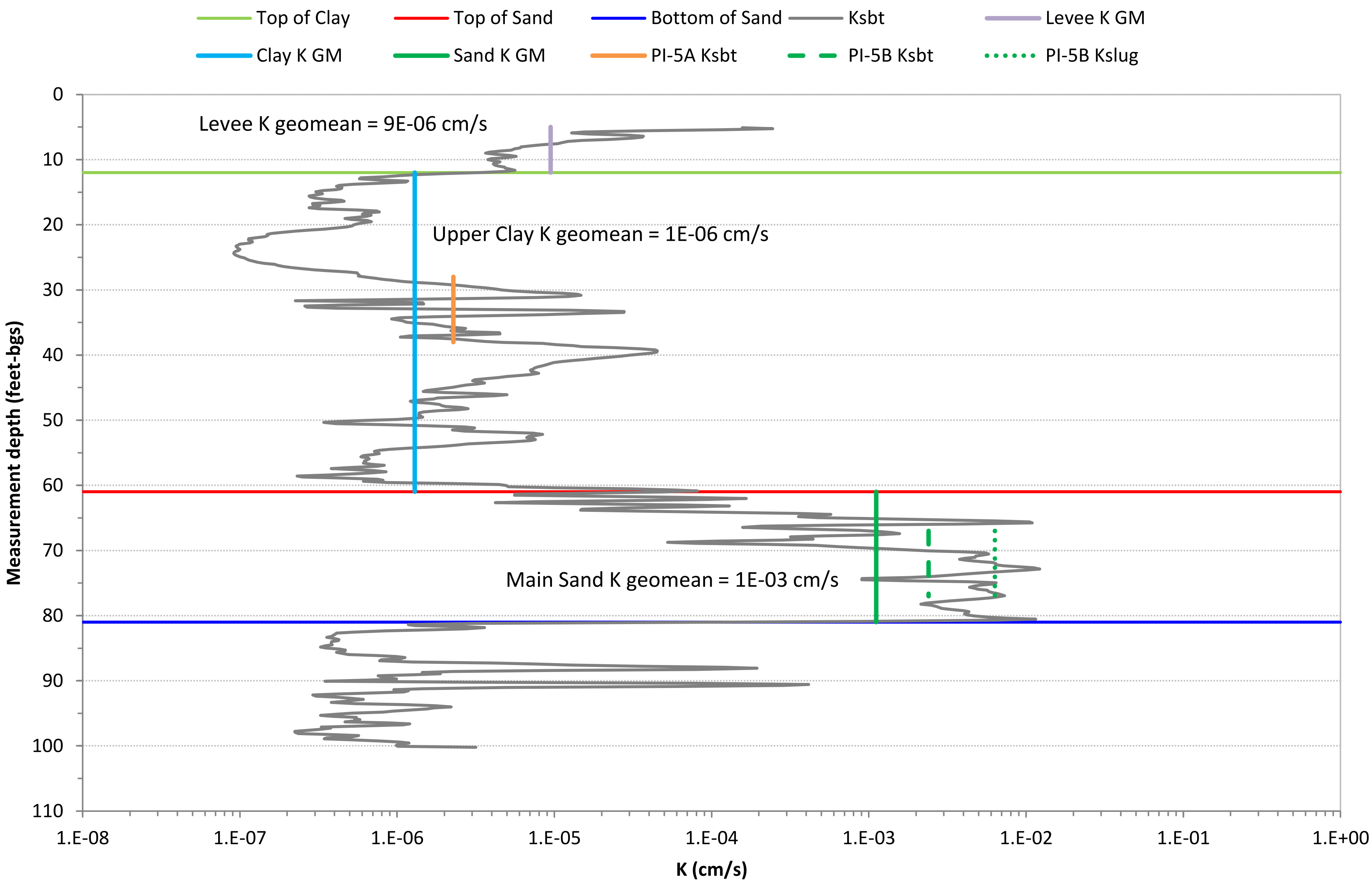


Appendix G-3. Summary of Hydraulic Conductivity Estimates
CPT PI-3
Top of Clay
Top of Sand
Bottom of Sand
Ksbt
Levee K GM
Clay K GM
Sand K GM
PI-3A Ksbt
PI-3B Ksbt
PI-3C Ksbt
PI-3B Kslug
PI-3C Kslug
Kppdt
Levee K geomean = 2E-05 cm/s
Upper Clay K geomean = 7E-07 cm/s
Main Sand K geomean = 6E-03 cm/s
Measurement depth (feet-bgs)
0
10
20
30
40
50
60
70
80
90
100
110
1.E-08
1.E-07
1.E-06
1.E-05
1.E-04
1.E-03
1.E-02
1.E-01
1.E+00
K (cm/s)

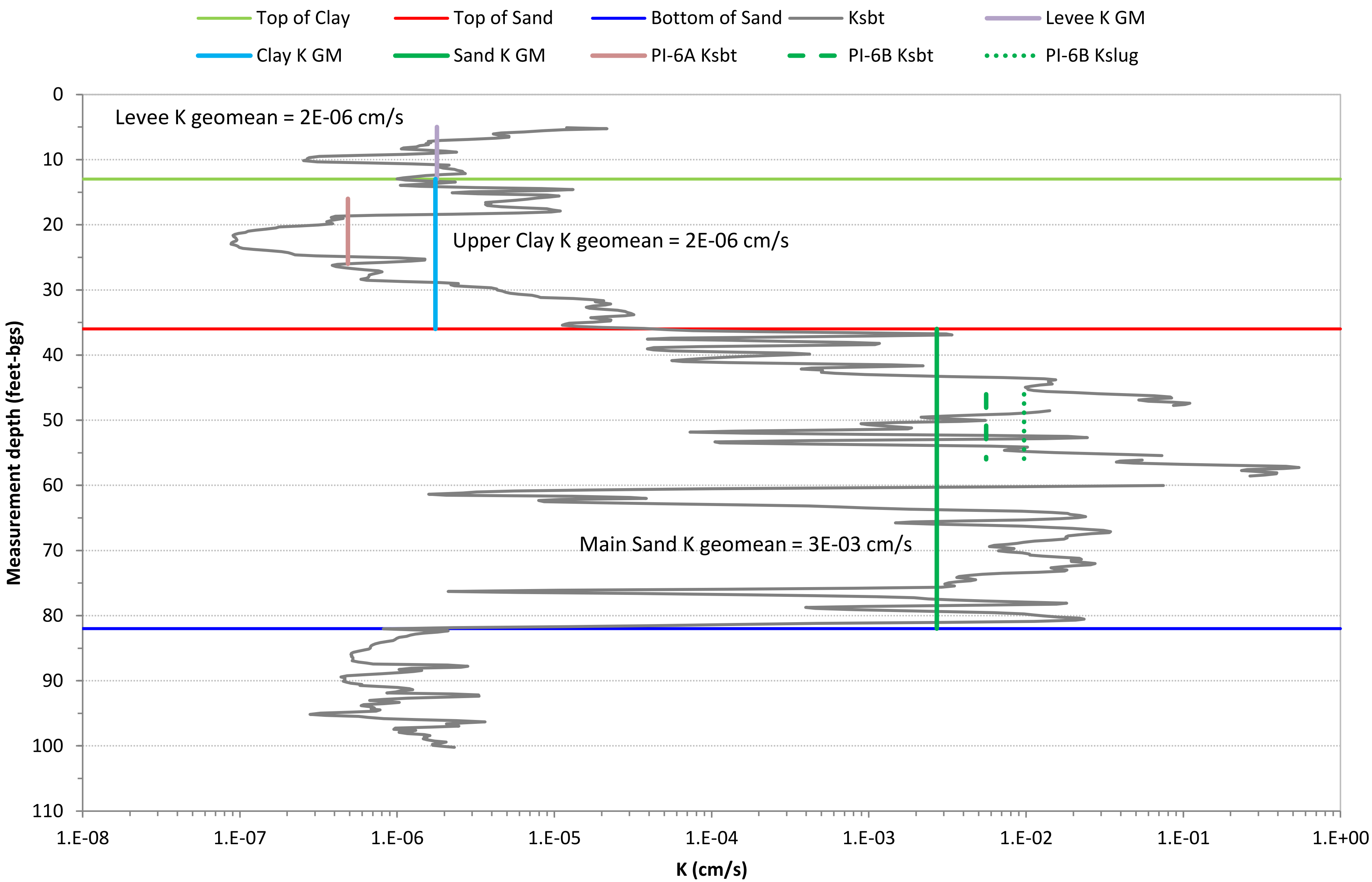
Appendix G-4. Summary of Hydraulic Conductivity Estimates
CPT PI-4



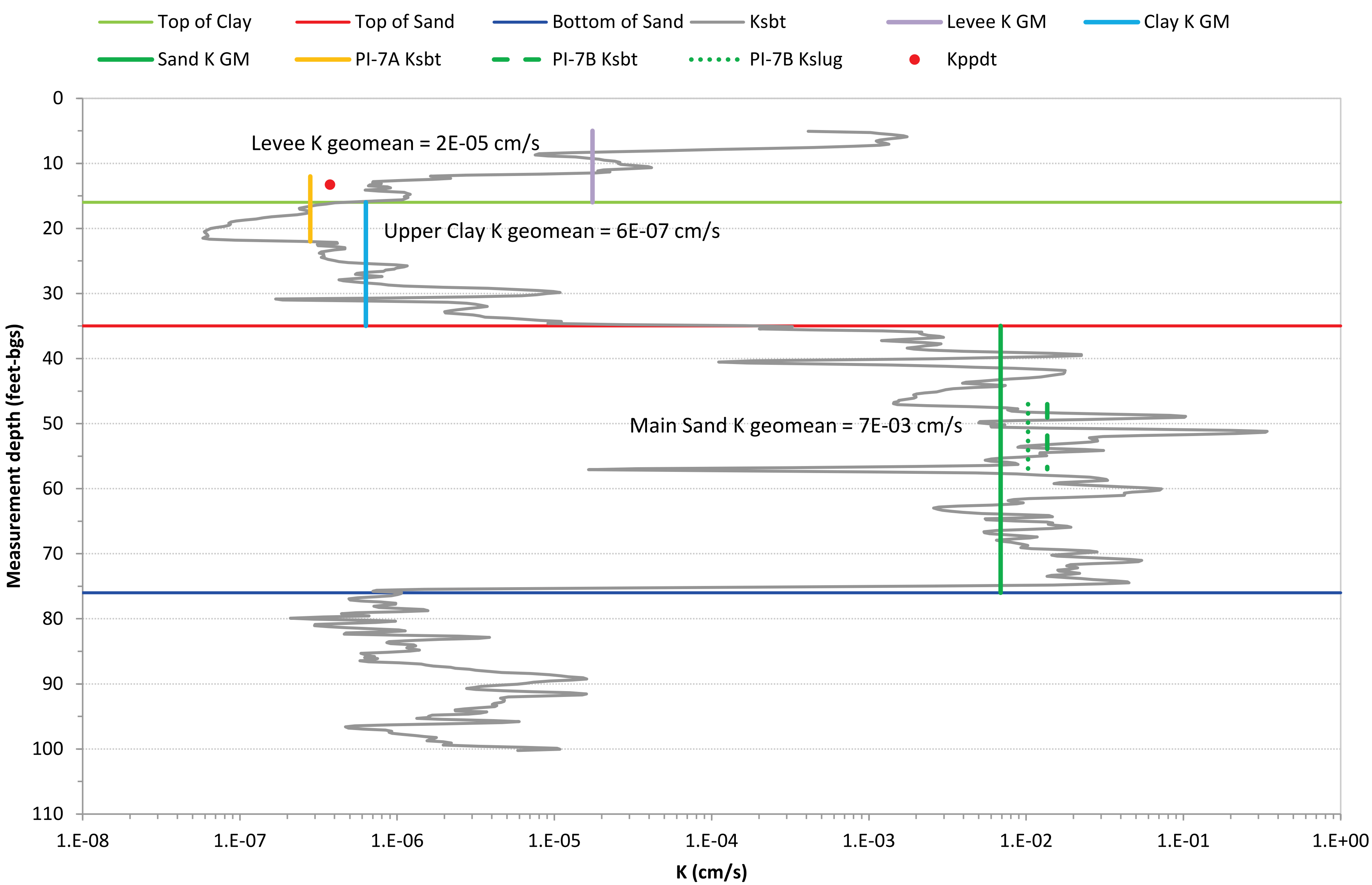
Appendix G-5. Summary of Hydraulic Conductivity Estimates
CPT PI-5

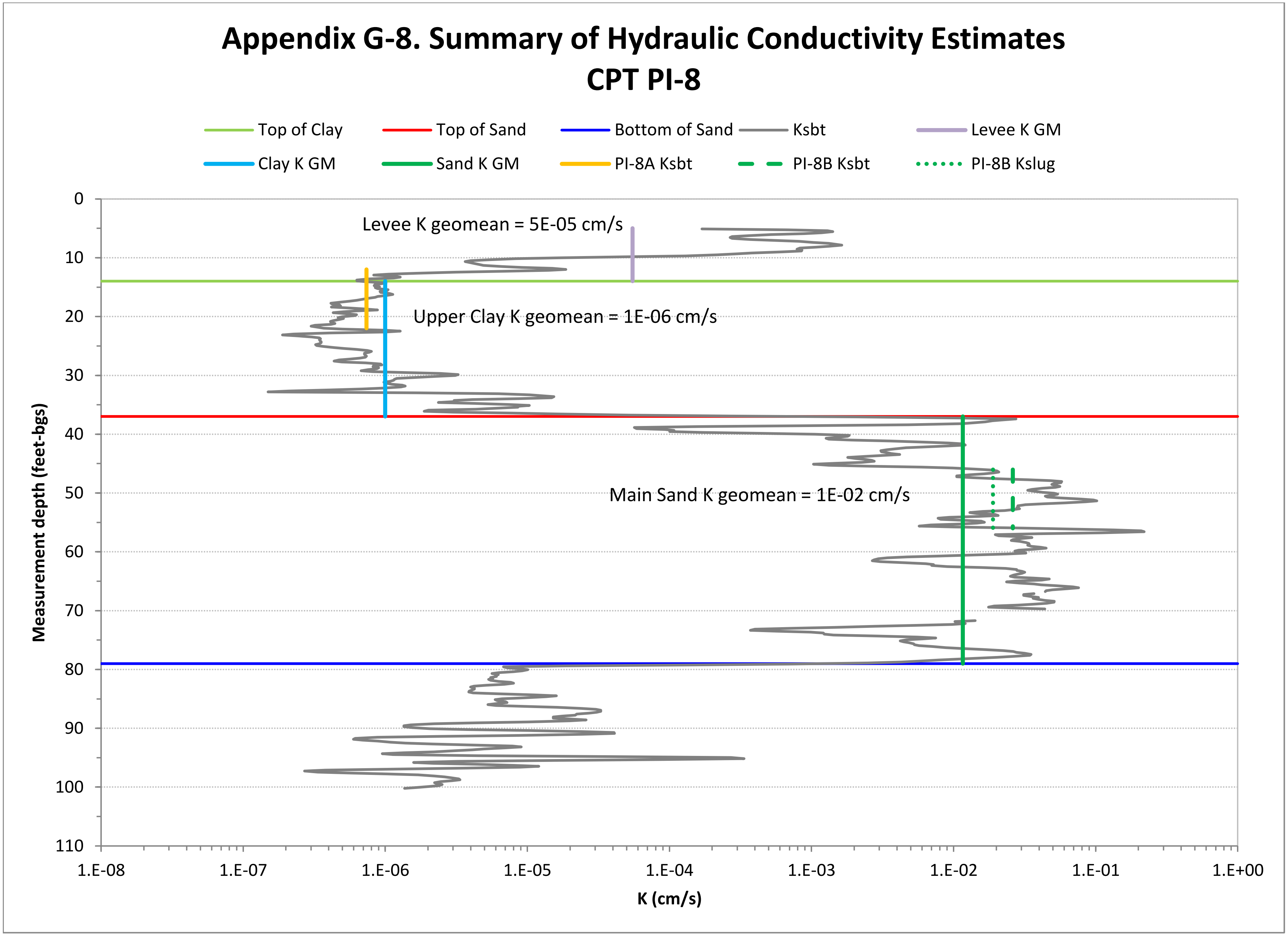


Appendix G-6. Summary of Hydraulic Conductivity Estimates
CPT PI-6

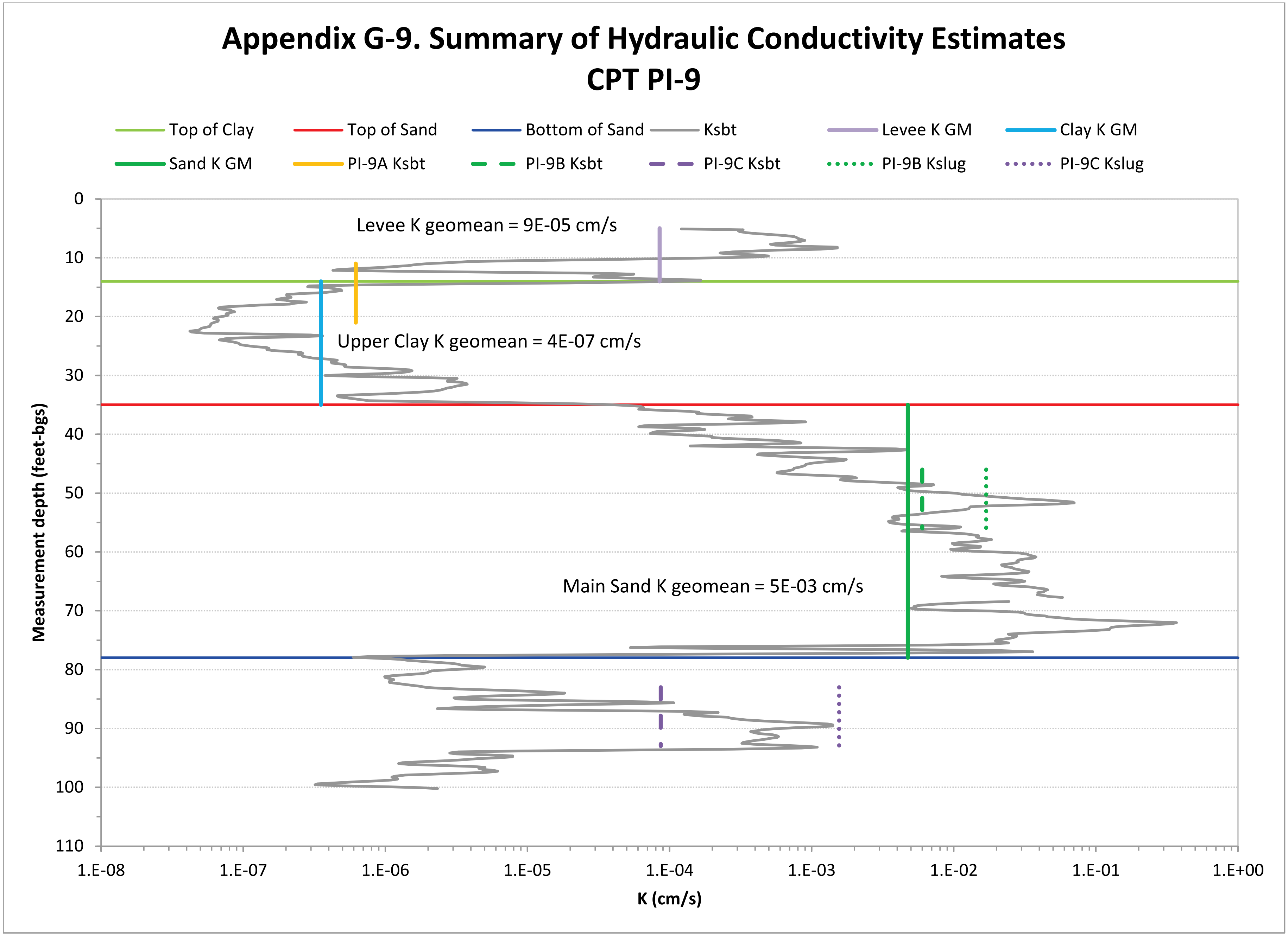


Appendix G-7. Summary of Hydraulic Conductivity Estimates
CPT PI-7

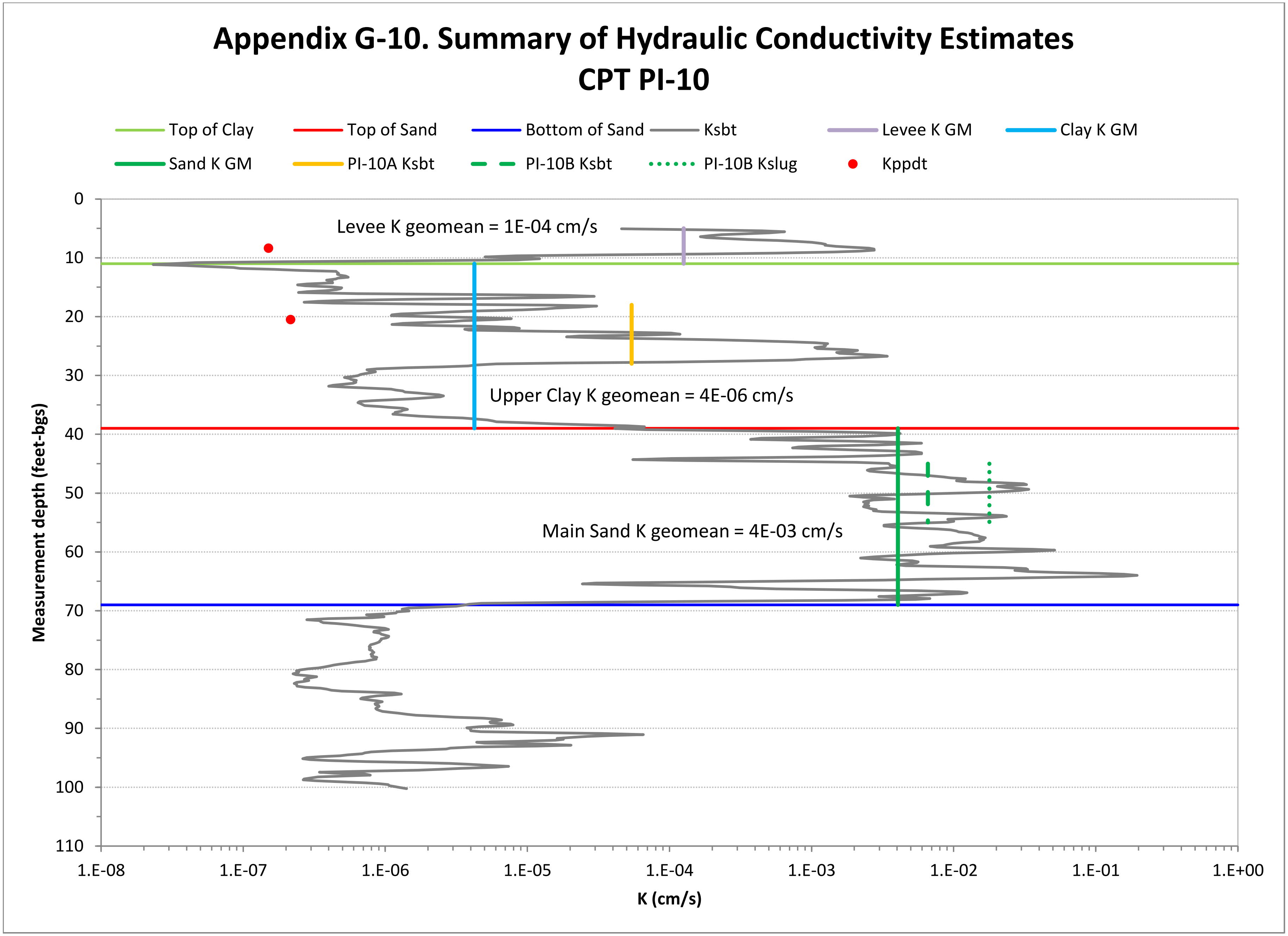




Appendix G-8. Summary of Hydraulic Conductivity Estimates
CPT PI-8
Top of Clay
Top of Sand
Bottom of Sand
Ksbt
Levee K GM
Clay K GM
Sand K GM
PI-8A Ksbt
PI-8B Ksbt
PI-8B Kslug
Levee K geomean = 5E-05 cm/s
Upper Clay K geomean = 1E-06 cm/s
Main Sand K geomean = 1E-02 cm/s
Measurement depth (feet-bgs)
0
10
20
30
40
50
60
70
80
90
100
110
1.E-08
1.E-07
1.E-06
1.E-05
1.E-04
1.E-03
1.E-02
1.E-01
1.E+00
K (cm/s)

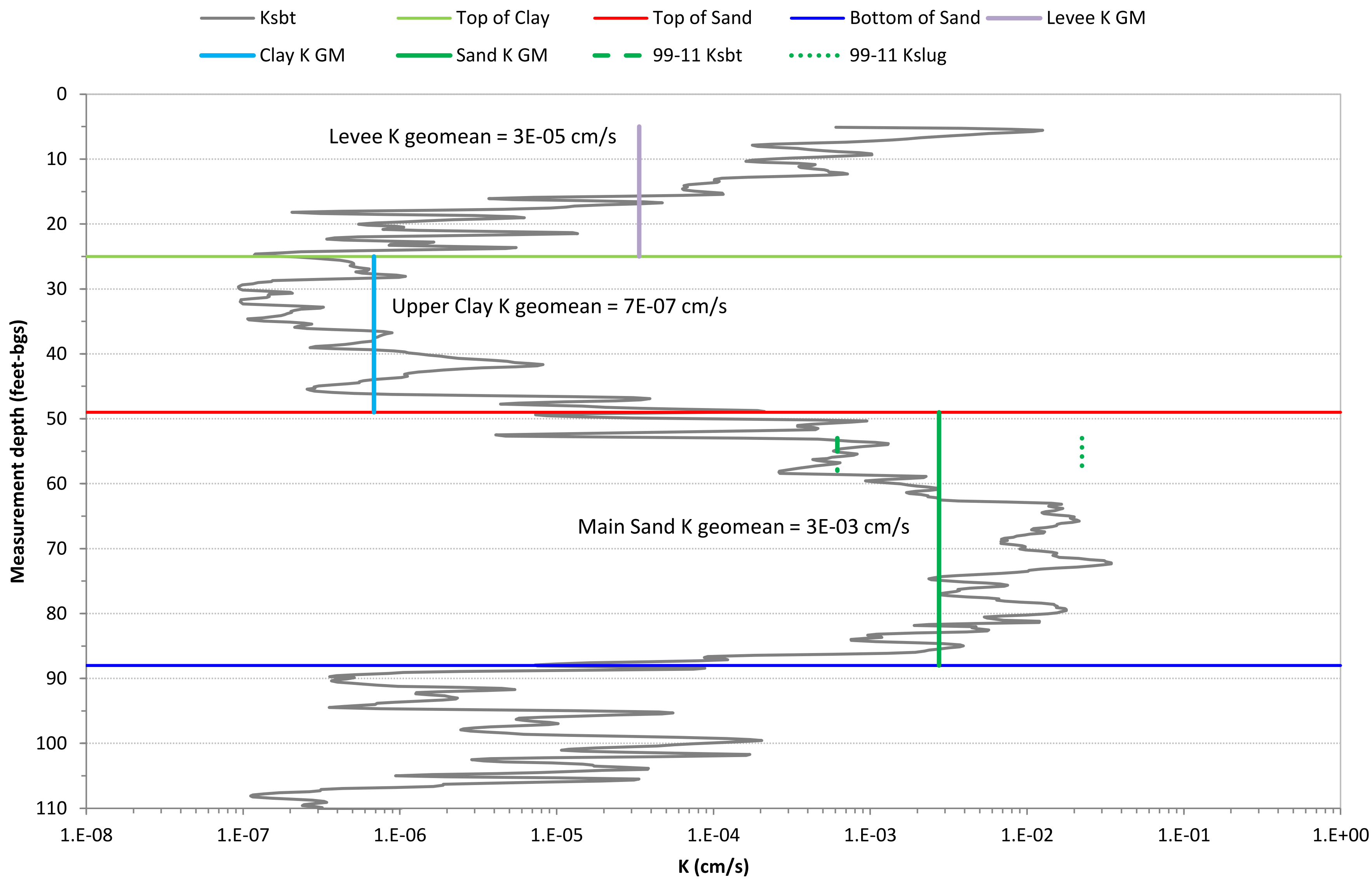


Appendix G-9. Summary of Hydraulic Conductivity Estimates
CPT PI-9
Top of Clay
Top of Sand
Bottom of Sand
Ksbt
Levee K GM
Clay K GM
Sand K GM
PI-9A Ksbt
PI-9B Ksbt
PI-9C Ksbt
PI-9B Kslug
PI-9C Kslug
Levee K geomean = 9E-05 cm/s
Upper Clay K geomean = 4E-07 cm/s
Main Sand K geomean = 5E-03 cm/s
Measurement depth (feet-bgs)
0
10
20
30
40
50
60
70
80
90
100
110
1.E-08
1.E-07
1.E-06
1.E-05
1.E-04
1.E-03
1.E-02
1.E-01
1.E+00
K (cm/s)

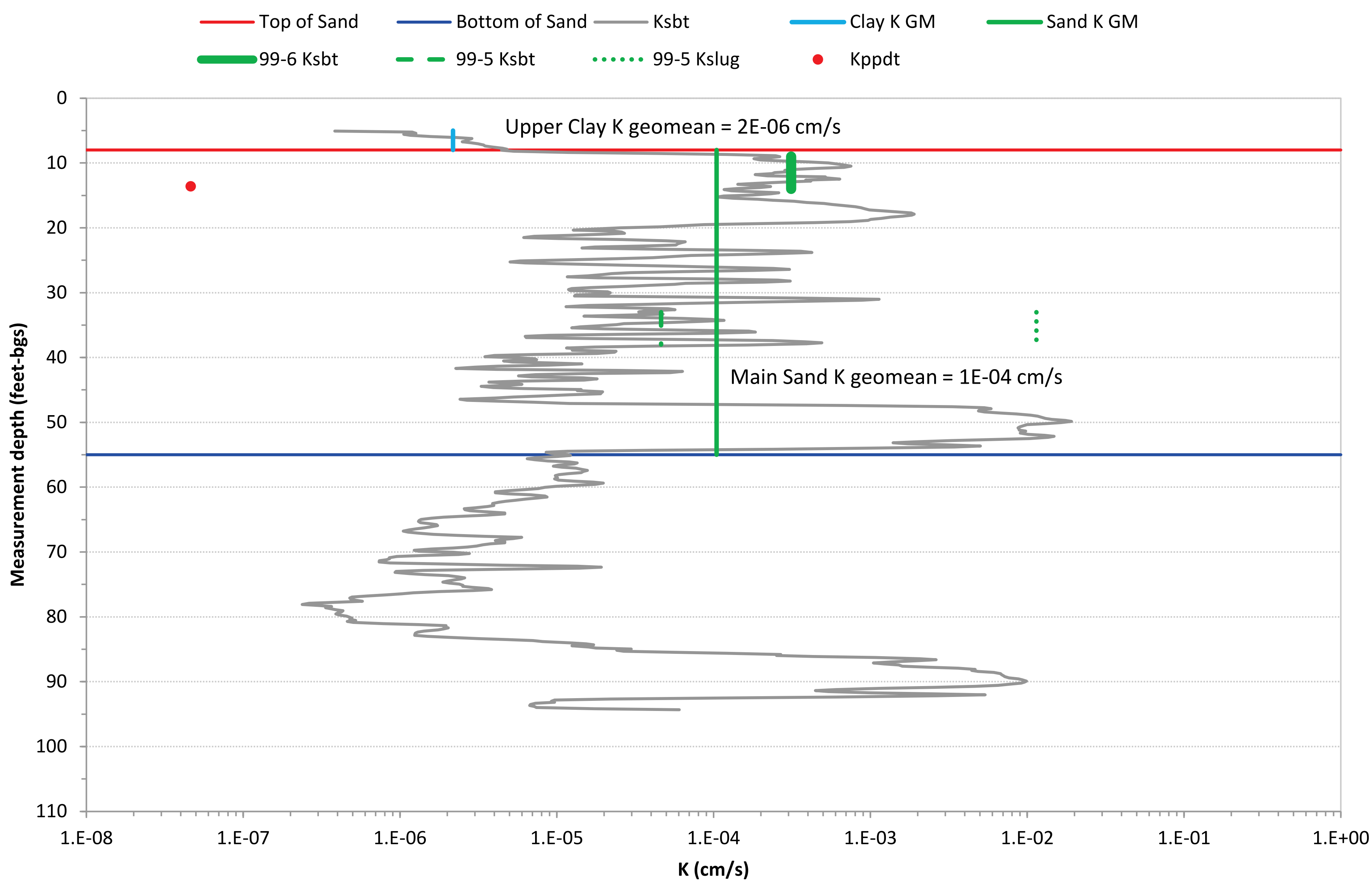


Appendix G-10. Summary of Hydraulic Conductivity Estimates
CPT PI-10
Top of Clay
Top of Sand
Bottom of Sand
Ksbt
Levee K GM
Clay K GM
Sand K GM
PI-10A Ksbt
PI-10B Ksbt
PI-10B Kslug
Kppdt
Levee K geomean = 1E-04 cm/s
Upper Clay K geomean = 4E-06 cm/s
Main Sand K geomean = 4E-03 cm/s
Measurement depth (feet-bgs)
0
10
20
30
40
50
60
70
80
90
100
110
1.E-08
1.E-07
1.E-06
1.E-05
1.E-04
1.E-03
1.E-02
1.E-01
1.E+00
K (cm/s)

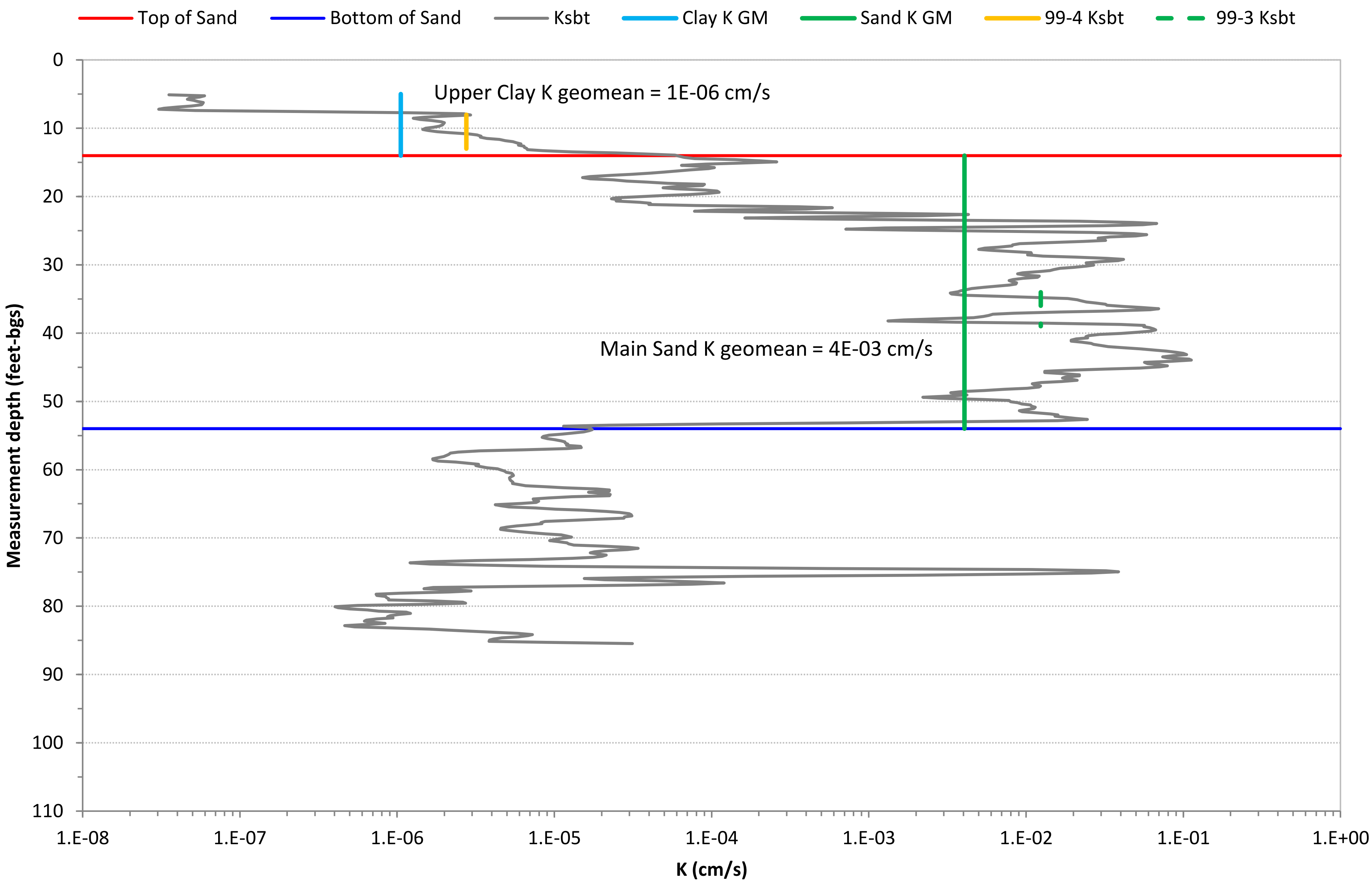
Appendix G-11. Summary of Hydraulic Conductivity Estimates
CPT RI-2



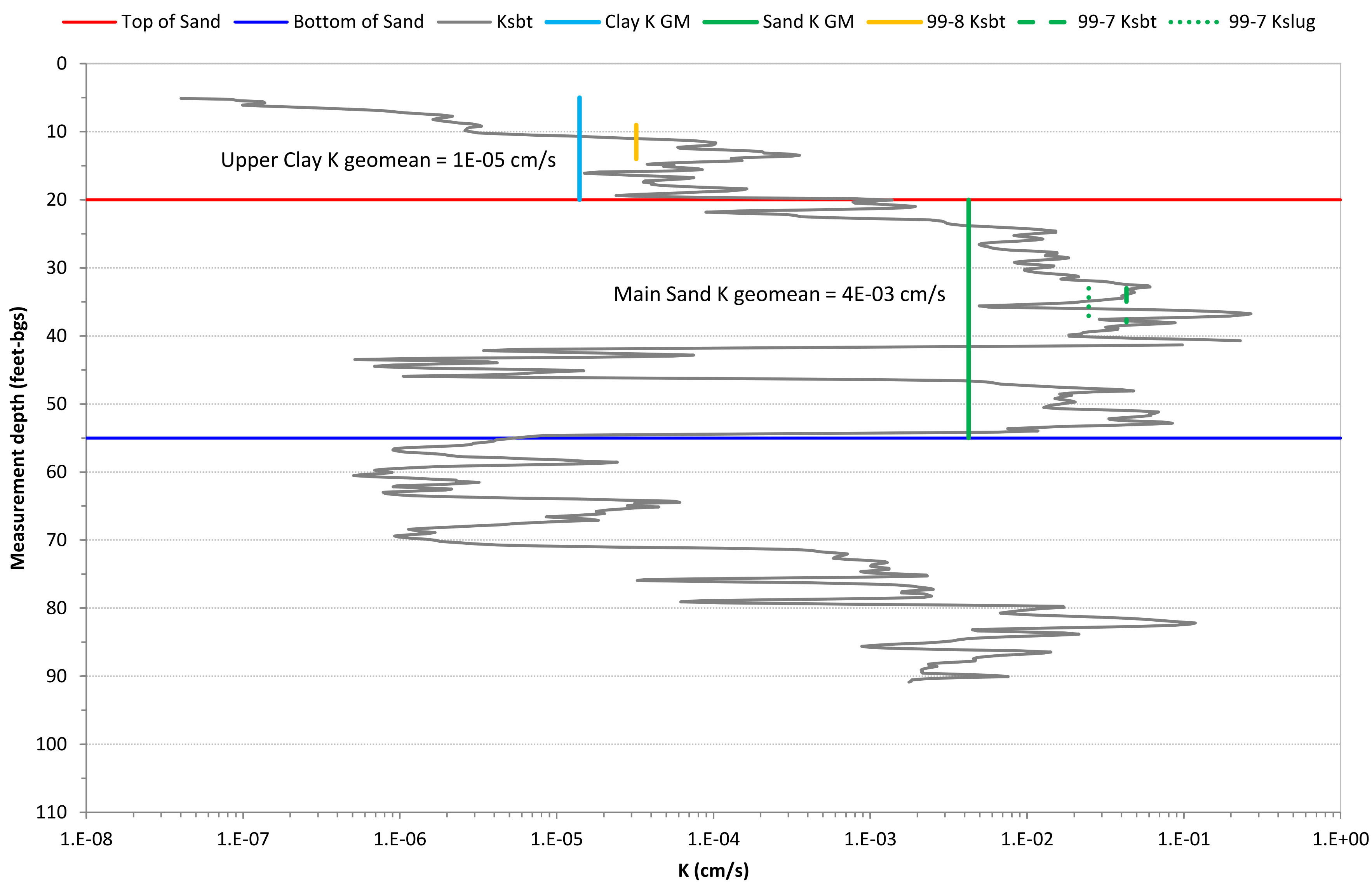
Appendix G-12. Summary of Hydraulic Conductivity Estimates
CPT RI-3

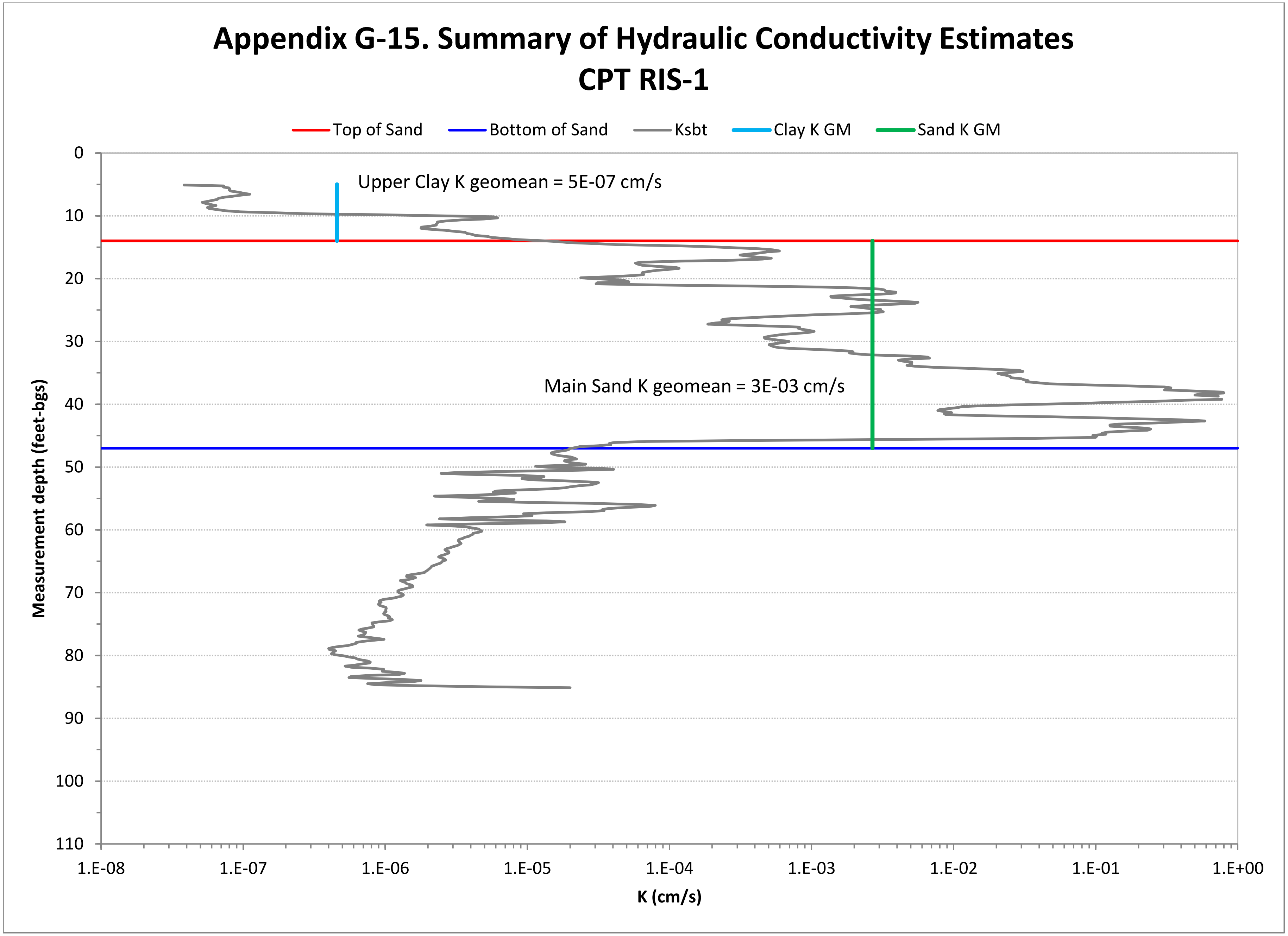


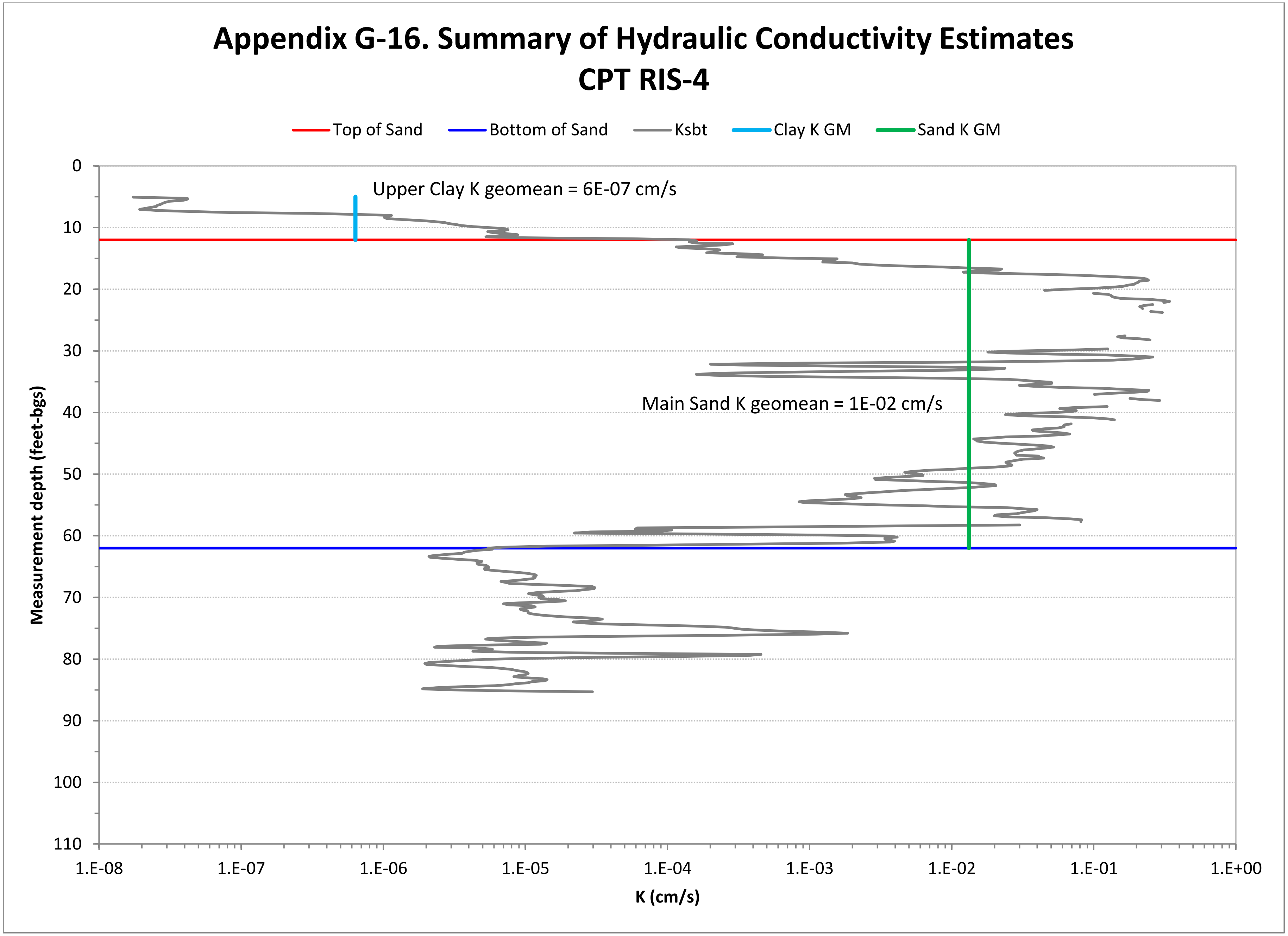
Appendix G-13. Summary of Hydraulic Conductivity Estimates
CPT RI-4

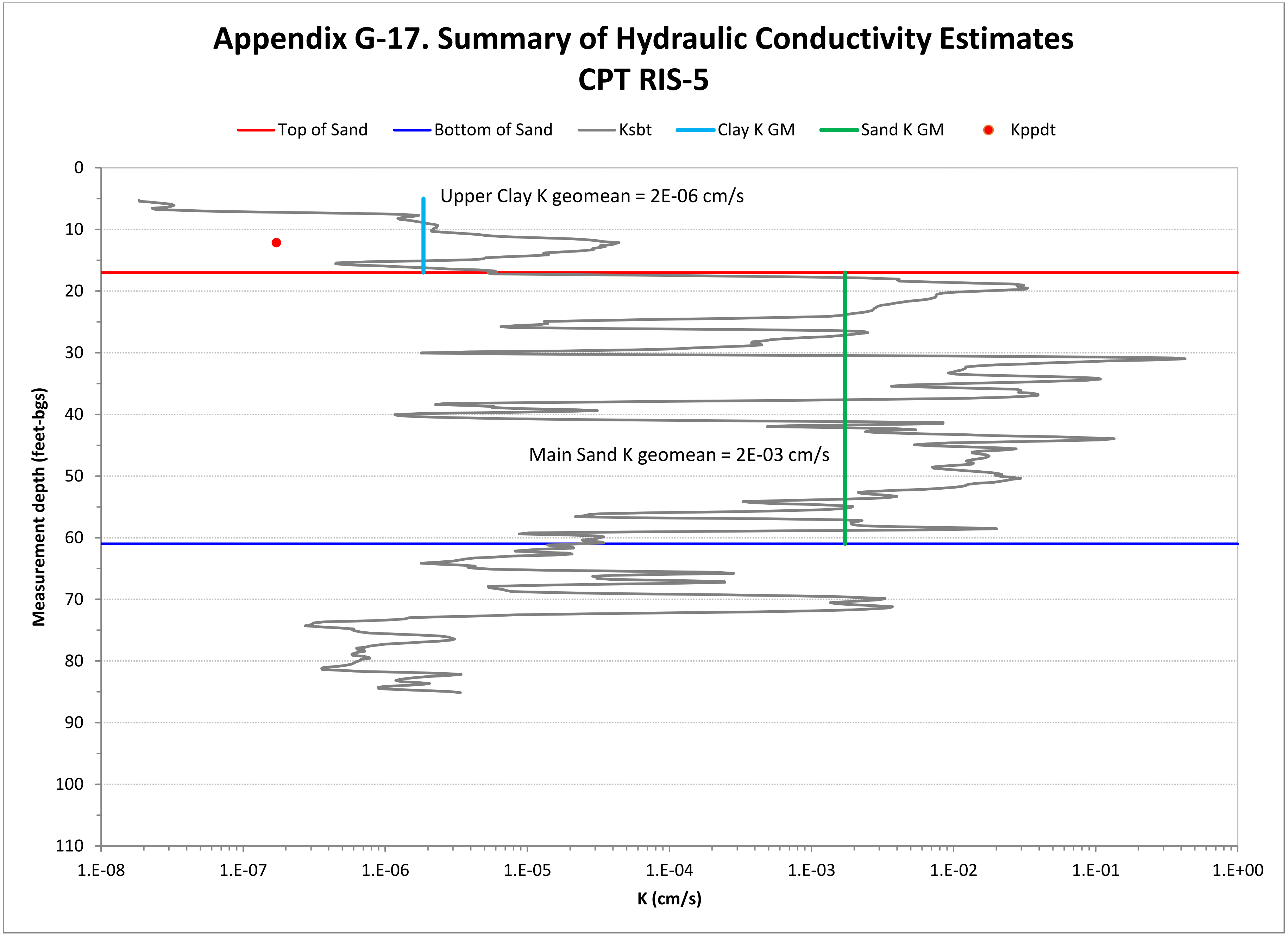


Appendix G-14. Summary of Hydraulic Conductivity Estimates
CPT RI-5

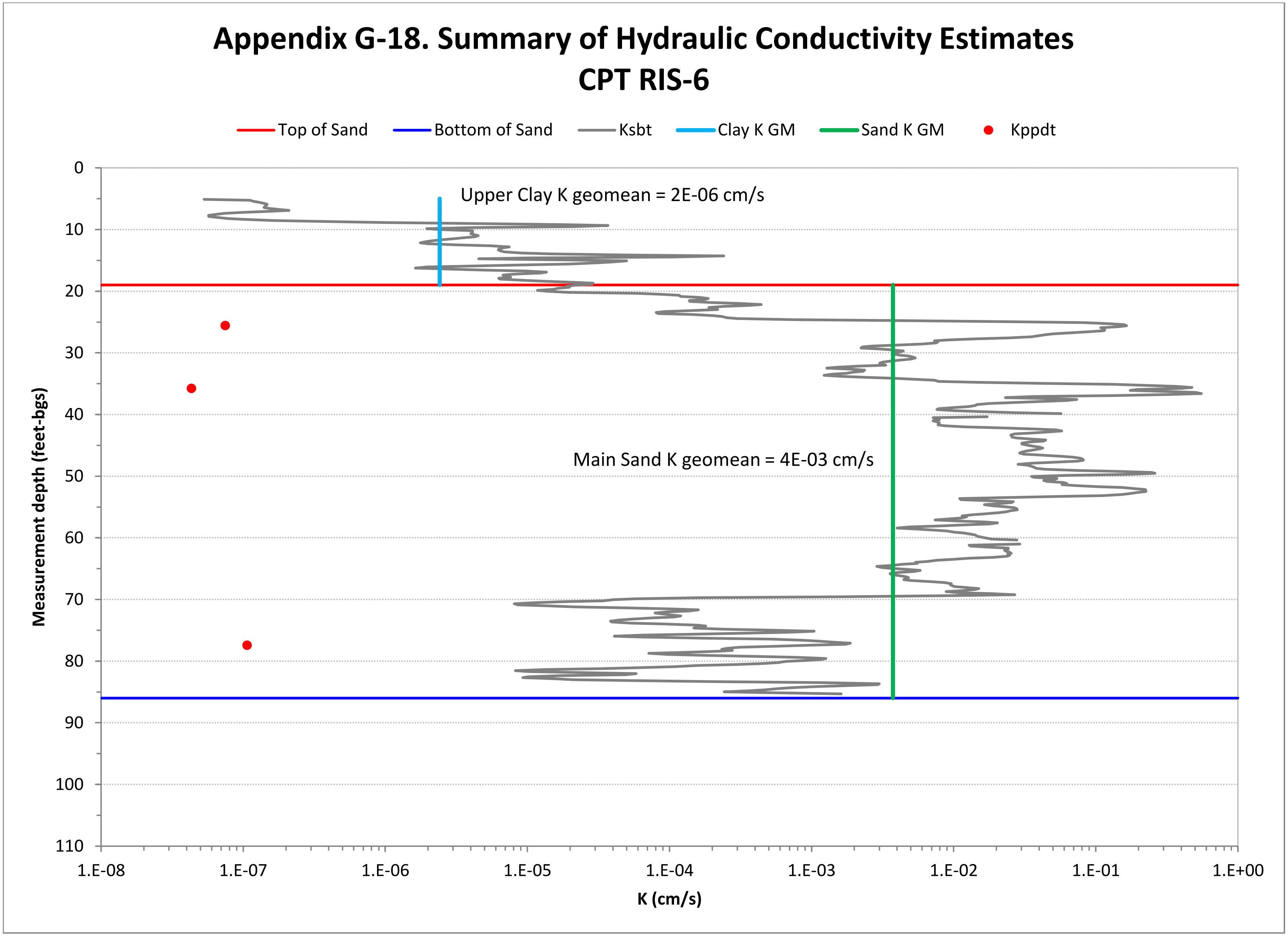



Appendix G-15. Summary of Hydraulic Conductivity Estimates
CPT RIS-1
Top of Sand
Bottom of Sand
Ksbt
Clay K GM
Sand K GM
Upper Clay K geomean = 5E-07 cm/s
Main Sand K geomean = 3E-03 cm/s
Measurement depth (feet-bgs)
0
10
20
30
40
50
60
70
80
90
100
110
1.E-08
1.E-07
1.E-06
1.E-05
1.E-04
1.E-03
1.E-02
1.E-01
1.E+00
K (cm/s)


Appendix G-16. Summary of Hydraulic Conductivity Estimates
CPT RIS-4
Top of Sand
Bottom of Sand
Ksbt
Clay K GM
Sand K GM
Upper Clay K geomean = 6E-07 cm/s
Main Sand K geomean = 1E-02 cm/s
Measurement depth (feet-bgs)
0
10
20
30
40
50
60
70
80
90
100
110
1.E-08
1.E-07
1.E-06
1.E-05
1.E-04
1.E-03
1.E-02
1.E-01
1.E+00
K (cm/s)



Appendix G-17. Summary of Hydraulic Conductivity Estimates
CPT RIS-5
Top of Sand
Bottom of Sand
Ksbt
Clay K GM
Sand K GM
Kppdt
Upper Clay K geomean = 2E-06 cm/s
Main Sand K geomean = 2E-03 cm/s
Measurement depth (feet-bgs)
0
10
20
30
40
50
60
70
80
90
100
110
1.E-08
1.E-07
1.E-06
1.E-05
1.E-04
1.E-03
1.E-02
1.E-01
1.E+00
K (cm/s)



Appendix G-18. Summary of Hydraulic Conductivity Estimates
CPT RIS-6
Top of Sand
Bottom of Sand
Ksbt
Clay K GM
Sand K GM
Kppdt
Upper Clay K geomean = 2E-06 cm/s
Main Sand K geomean = 4E-03 cm/s
Measurement depth (feet-bgs)
0
10
20
30
40
50
60
70
80
90
100
110
1.E-08
1.E-07
1.E-06
1.E-05
1.E-04
1.E-03
1.E-02
1.E-01
1.E+00
K (cm/s)